A

TREATISE

ON THE

Progressive Endeavours

TO IMPROVE THE

MANUFACTURE AND DURATION

OF

CORDAGE:

WITH A DISCUSSION ON THE

MEANS OF CAUSING

SHIPS TO RIDE AT ANCHOR

WITH

Greater Safety.

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INTRODUCTION.

THE chief motive to the commencement of this Essay, was to introduce to public notice some inventions, which led me to become a manufacturer of ropes; and which, although useful in themselves, have hitherto repaid me very inadequately for the time and expense bestowed:—but at the same time I can lay claim to more patriotic and disinterested views; amongst which are my endeavours to point out the means of enabling ships to avoid the loss of their anchors and cables, and to ride with greater safety under hazardous predicaments: and if a single ship should be saved by the adoption of the proposed measures, I shall feel myself amply rewarded. The subject is of national importance; as by ships parting from their anchors, many brave defenders of our country are annually lost; and property to the amount of, I conceive, not less than a hundred thousand pounds.

As to the manufacture of hemp into Cordage, and the preservation of it from the dry rot, it forms, at the present period, an object of the highest inportance in our national economy, when the state of war of this country with half the civilized world precludes us, in an essential degree, from the attainment of the raw materials requisite for the fabric of cordage, which is a *sine quâ non* for our navy, both military and commercial: the annual amount * of these mate-

* The import last year into Great Britain, was, From St. Petersburg 23,077
Archangel 660
Riga 12,017
35,754 Tons.

The quantity from Riga includes that sent to Ireland, which will be compensated for by the hemp from Koningsburg and other small ports; so that the hemp to Great Britain alone may be taken at 37,750 tons. The quantity of hemp direct from its places of growth to Ireland is not very considerable.

rials, at the present prices, is nearly three millions sterling; and in peaceable times, upwards of one million and a half. Our *independence of Russia* for the supply of the most essential article, will, I trust, soon arise from the efforts made by Government to obtain hemp from Ireland, from Canada, Trinidad; and the hemp itself, with its different substitutes, from the East Indies, all of which are particularly described in Mr. Wissett's "Treatise" on that article; also, the mode of raising it at home, is shewn in the Appendix by Lord Somerville, which it may be hoped will be attended to, as the present high prices form a more operative bounty than what was formerly paid in this country; and which, whilst it continued, was sufficient to induce a considerable quantity to be grown annually in Lincolnshire, Dorsetshire, and Somersetshire, which did not altogether cease with the bounty. As to the substitutes for hemp; the *Kantala* of Bengal, or fibrous part of the leave of the American aloe, is to be had in considerable quantity from St. Domingo, and of a sufficient length of fibre (viz. from three feet to three feet ten inches), and stronger than the Sunn of Bengal, *so far as appears* from the following experiment made on a small rope brought from St. Domingo by Captain Goodall, a gentleman of some celebrity, from the part he has taken in the affairs of Hayti. This rope, girted very correctly $\frac{11}{16}$ths of an inch, had two threads in each strand, and sustained $3\frac{3}{4}$ cwt. at the point of breaking, which is equal to 7.1 cwt. per inch of the square of its girt. A moderately good white rope will carry 8 cwt. per inch; but if of fine yarns and well made, will bear 12 cwt. per inch. The elongation, at the point of breaking, was one-sixth of its original length. The specimen was too small to draw any decided conclusion from it, further than that, upon the new principle of manufacture, as good cordage (of a large size) may probably be made from this Haytian product, as from good hemp manufactured after the usual manner, which is yet by far the most prevalent. The American aloe grows wild in St. Domingo in great abundance; and the plains near Cape François are, by Mr. Goodall's account,

very suitable for the growth of hemp; therefore he is now preparing to take out a considerable quantity of hemp-seed to make the experiment.

From the combination of all the preceding circumstances, we may have reason to expect, that the continuance of war cannot deprive us of the means of supplying our ships with cordage. It nevertheless is expedient to lessen as much as possible the immense annual waste of that article.—Such portion of it as takes place from actual wear, cannot be much diminished; but so much of it as arises from the use of an imperfect preservative (and which, in hot climates, is a large proportion) may, it appears, be considerably reduced by depriving tar of its noxious qualities, and supplying their place with animal oils, or suitable expressed oils, so as to form the compound into a plastic innoxious wax, which will at the same time resist water, and cause the rope, preserved with it, to continue pliable in any climate, and retain its strength with little deterioration. —The oil most suitable for the recited purpose, appears to be whale oil: rape-seed oil, upon which some experiments have been made, also answers a good purpose; but I conceive will prove inferior to the animal oil.—Linseed oil obviously cannot rank amongst the suitable expressed oils; because it is well known, that, in several instances, it has occasioned ignition where it has been spilt upon hemp lying in store.—What is here attempted to be produced by art, as a preservative for cordage, it appears may be acquired by using the tar of the teak tree. In May 1805, Sir Joseph Banks, who, with praiseworthy zeal, attends to the improvement of the manufactures of the country, procured a trial to be made of the teak tar, to learn how far it would act as a preservative for rope; for which purpose two three-inch ropes were made of the same yarns, one with teak tar, and the other with that in common use. They were then placed in the same storehouse, and, on the 28th of September 1807, they were broken.

lbs.

The common tarred rope broke with . . . 3848

That made with teak tar broke with . . . 5980

therefore, after being kept about two years and a quarter, the common tarred rope was rather less than two-thirds of the strength of the other. The artificial preparation has not been contrasted with common tar for such a period; but so far as can be judged from the experiments recorded under the head of the XXIst Invention, it will probably maintain as decided a superiority.

As my own inventions form a portion of those recorded in this Treatise, I have spoken of myself in the third person, that I might avoid unnecessary egotism, and preserve uniformity in the manner of description. Wherever the inventions have been secured by Patent, and their specifications published, reference has been made to the works where they are to be found, that the Reader may have the means of acquiring a more minute knowledge of each invention than can be obtained from the concise description in this Treatise.

CONCISE REMARKS

ON THE

MANUFACTURE AND DURATION OF CORDAGE.

THE manufacture of cordage has its origin in the remotest antiquity; and, until the close of the last century, appears to have undergone no improvement in its principle; which consisted only in the application of twists, in directions contrary to each other, so as to prevent the threads or yarns, which form the first constituent part, from opening out, and admitting the fibres of hemp or flax, or other component substance, to disengage themselves and draw asunder.

The first part of the process consists in the spinning of a single thread, which, unless very small, and gummed similarly to the animal processes of the silk-worm and spider, would tend to untwist itself when at liberty; therefore, even in sewing-thread and twine, it will be found that there are two or more constituent threads joined, by being twisted round their common axis, in a direction contrary to their individual twist: but this principle is only capable of being carried to a limited extent; because, whenever the threads are very numerous, their proportionate diameters are so small, compared to that of their combined mass, that they are not capable of counterbalancing the twist of the strand they compose, and preventing its opening out. Therefore three of these combined masses have, from time beyond record, been joined together by another contrariety of twist; and these form what is generally called a rope, technically a shroud-laid rope. The

first combination of yarns forms what is called a strand*; three of which being stretched at length, are attached at one end to three contiguous but separate hooks, and at the other to one single hook; and the process of their conjoint combination, which is performed by turning the single hook the contrary way to the other three, consists in regulating, by duly retarding it, the progress of the twist of the strands round their common axis, whilst, at the same time, the three strands receive separately, at their opposite ends, just as much twist as is taken out of them by their twisting the contrary way in the process of combination.

This, in all probability, was the extent to which rope-making arrived for many ages; because the magnitude of ships, or the other applications of rope, did not formerly require that vast size which rendered further combination necessary. The individual yarns composing a strand are limited in their thickness; because, if exceeding a given size, the fibres of hemp, or other component substance, have not a sufficient number of turns round their common axis to prevent their slipping on the yarn being stretched: therefore, when the rope became thick, the requisite number of yarns to form a strand was exceedingly great, and, in general, many were broken on their being twisted together in one spiral; because the outward coat of threads or yarns was exposed to more stress than the internal ones, as will be very evident when it is considered that when two or three hundred yarns are all stretched at length, to form one cylindric mass, they will lie at different distances from the centre of that cylinder; and that when twisted together, the outside yarns form a spiral of some given number of turns round the mass of the included yarns, forming a considerable diameter, and are therefore much shortened; whilst the inner yarns take only the same number of turns round a reduced axis, and, from that cause, should be less shortened: therefore it follows that the outside yarns only can be in full tension; whilst those within must be more or less puckered up according to

* In some instances four, besides a central core.

their proximity to the centre.—The result of this erroneous principle of forming strands (although its cause appears to have lain dormant) was obvious, and probably led to the formation of great ropes, by the combination of the lesser ones round a common axis, in the same manner as a shroud-laid rope is already described to be formed by the combination of strands round their common axis;—and the rope, thus formed by the combination of three shroud-laid ropes, is said to be cable-laid; as, upon this principle, cables and water-ropes are made, even when their magnitude does not require their strands to be inconveniently large; the cause of this construction being to make the rope more hard and compact, and thus prevent the too easy admission of water, which would occasion the rope to rot, when frequently taken out of the water, and retaining it internally.

The short duration of ropes exposed to be alternately wet and dry, necessarily led to the invention of some simple and unexpensive preservative, which, by the general practice of maritime nations, has been supposed to be best effected by the use of boiling tar, through which a mass of yarns, generally consisting of two to three hundred, are slowly drawn, and compressed on leaving the kettle, so as to discharge the superfluous quantity.

In this state, the art of rope-making continued to near the close of the last century, and, with a few exceptions, continues to this day.

It now follows to relate the attempts at improvement; these have been made on two distinct principles; one to facilitate the process, and the other to improve the quality of the manufacture.

I. The first attempt that I know of was made by a Mr. Sylvester, who deposited a model of his machine in the repository of the Society of Arts in the Adelphi, prior to the year 1783.

The design of this machine was to supersede the necessity of a rope-ground, by enabling the process to be carried on in a house: for this purpose he spun the thread on a bobbin and spindle; and, by his model, the yarns requisite to

make the strands were wound on three separate reels, fixed on frames which turned individually round their axes, and also round a common centre, by which they were all three twisted together into a rope, which was to be wound up, or coiled away progressively as made. The great defect of this machine was, that the process of making the strands, and twisting them into a rope, did not proceed at the same time; but a portion of the strands was first made, and afterwards twisted into a rope, imitating, I presume, the process in a rope-ground, where the strands and rope are made in separate operations, at full length, and not foreseeing that, where short portions are alternately made, the twist must necessarily be disarranged, more particularly at the points of termination of each respective change.

This invention, such as it was, was offered gratuitously to the public, but I believe never carried into effect.

II. So far as has come to my knowledge, which I request to be also attended to in those I have subsequently to relate, the next invention was secured under His Majesty's Letters Patent in 1784, to a Mr. Benjamin Seymour, for a new method of making ropes. This appears to have been a method of substituting horses in the place of men to move the machinery at the head of a ropery, viz. the twisting of the strands during all the different processes, until completed in a cable. It was tried in the King's yard at Plymouth, and laid aside.

III. On or about the 15th of May 1792, the Reverend Edmund Cartwright obtained a Patent for a machine for making ropes, which he called a cordelier.

This machine was so far similar to Mr. Sylvester's, that three separate reels, containing the yarns to compose the strands, were placed on as many frames, each turning round its individual axis, whilst the whole moved round an axis common to the three; but it differed essentially from the former, by both these motions proceeding at the same time; so that the twisting of the

strands and of the rope kept pace with each other; and were therefore capable of producing the desired end, the rope being progressively drawn away as made. This machine has formed the basis of subsequent Patents.

IV. On April 12, 1793, Mr. Richard Fothergill, of Sunderland, in the county of Durham, obtained His Majesty's Letters Patent for "a machine for dressing hemp, and making and spinning the same into ropes and cordage."—This invention consisted in a method of heckling and preparing the hemp, and in spinning it into rope-yarn; and in laying the cordage by a machine on the principle of Mr. Cartwright's, differing in its being vertical like Sylvester's, whilst the revolving shafts of Mr. Cartwright's were horizontal, and more particularly in its internal regulations. It was capable of making ropes without the necessity of a rope-ground; but excepting so far as any advantage may arise from the greater uniformity of the whole process, went only to the reduction of labour, and concentration of it to a more limited space.

It was, however, carried into effect upon a very large scale, and at a great expense in buildings and machinery, at Southwick, on the river Wear; but very limited indeed as to the manufacture, until such further improvements were adopted as will come in the course of narration. I have given the description of this invention a little out of its chronologic order, on account of its similitude to the preceding patent; and also because the two inventions next described are closely connected with each other*.

V. On March 16, 1793, Mr. John Daniel Balfour, of Elsineur, in the kingdom of Denmark, obtained His Majesty's Letters Patent for his "new-invented machine for making and manufacturing ropes and cordage." This was an attempt, and a very just one, so far as it went, towards improving the principles on which cordage is manufactured. I have already de-

* Engravings of the drawings of this Patent are given in plate I.

scribed the usual process of forming the strand of a rope, and shown that it must be defective; because a given number of spirals round a large cylinder, must require a greater length of yarn than the same number of spirals round a small cylinder, of the same length of axis as the large one.

To remedy this defect, Mr. Balfour's method was to stretch out at length on a rope-ground all the yarns wanted for the formation of a strand, to such length as the strand was required to be; the residue, viz. so much at least as the length of the yarns would exceed the proposed length of the strand, was to be wound up on as many individual bobbins upon a large frame as there were yarns. Those yarns were separated at intervals, throughout the whole length from the frame to their commencement, where the operation of twisting the strand was to begin. Here the yarns were all united, either through concentric circles of holes, or round the notches of an implement which he called a top minor. The operation then began by twisting the whole of the yarns in mass at that end, and retiring with the top minor as the twist advanced. In this case, as the yarns at the opposite end had the means of drawing off individually from their separate bobbins; they each would unwind no more than their internal or external position in the spiral required, and would, of course, be of different lengths. This plan was very ingenious, and had much merit in its principle, although defective in stopping short of what would effect the ultimate purpose of causing all the yarns to bear alike on breaking the rope. Before a rope is brought to its breaking stress, both it and the strands composing it are much elongated, and their diameters greatly reduced. Now, under any reduction of diameter of strand, it is apparent that the outside coat of yarns must slacken considerably, and give no support to the internal yarns, which, from the smallness of their spiral, could elongate but little, and must, of course, break in succession from the centre outwards. In addition to this defective circumstance, the mode of operation was so complex and laborious as to prevent its adoption *.

* The specification of Mr. Balfour's patent has been published in the second volume of the first series of the Repertory of Arts.

This invention of Mr. Balfour's, although defective and nugatory (because, if ropes were made accordingly as he has directed, they *should be even, as a sine qua non,* viz. by taking the greatest care to put no additional twist into the strands after being made from the bobbins; they would then be worse than common made cordage), has nevertheless been the basis of all future improvements. The means of remedying the defect had suggested itself to others before they knew of its having been discovered by experience.

VI. This deficiency, in point of principle, was remedied in a Patent taken out about April 25th, 1793, by Mr. Joseph Huddart, of Islington, in the county of Middlesex, for "a new mode or art of making great cables and other cordage, so as to attain a greater degree of strength therein, by a more equal distribution of strain upon the yarns."

This followed Mr. Balfour's so immediately, that Mr. Huddart may fairly be supposed to have also been an inventor of the application to cordage of the principle introduced by Mr. Balfour, who adopted it from a practice he had seen amongst the negroes in the West Indies, in their making a certain description of lines.

Mr. Huddart's formation of the strand is essentially the same process, excepting that he places, behind the moveable implement which Mr. Balfour calls a top minor, a tube of two parts, divided longitudinally, and overlapping each other, which is formed of thin steel, of spring temper, to be more or less compressed at pleasure.

The top minor of Balfour is with Mr. Huddart composed of a plate with the requisite number of holes for the yarn, placed in concentric circles; and connected with this plate at such a distance as to admit the easy concentration of the yarns, is the tube just spoken of, which is united to a graduated instrument, called by Mr. Huddart a register, on which there is an index to denote the proper angle of twist during the process now described, and which is also used to regulate the increased angle of the next process. The

yarn reels were placed individually in a stationary frame at the head of the rope-ground; and it appears that the register was to be conveyed onwards towards the yarn frame, as the strand was twisted by the hook of a sledge, at the end where the process commenced, until the whole strand was made.

This part of the process is similar to Balfour's, which Mr. Huddart perfected by giving to the mass of yarns, thus formed into a strand, an additional twist, by which the strand was shortened, and provision made for the effects described to be produced by the reduction of its diameter on being stretched.

In point of principle the plan described by Mr. Huddart was complete, but his mode of carrying that principle into effect was so far complex and laborious, that, excepting the making a few ropes by way of trial, and which proved far superior to the common manufacture, the invention lay dormant, and was relinquished. Mr. Huddart's specification * also included a method of twisting the yarns, during the process of their being formed into a strand, as a preventive to their loss of strength by untwisting so much as the counter-twist of the strand would otherwise occasion.

VII. Mr. William Chapman, of Newcastle, on Sept. 13, 1797, obtained a Patent for "laying, twisting, or making ropes or cordage of any number of yarns or strands, or any number of threads tarred or untarred, from the size of a cable down to the smallest line, composed of more than one thread." This invention was principally to reduce the charge of labour, and to render rope-grounds unnecessary. The strands revolved round their own axis only, and the rope was formed by the revolution of a distinct axis or frame on which it was coiled;—it was capable of making, *on the common principle*, shroud-laid ropes and cables of any size, and dispensing with the use of a rope-ground. The essential difference between this invention and those described as the 3d and 4th, is, that the parts of the machine which twist the strands are less cumbrous and complicated than by the planetary revolution of the strand frames: but whatever is gained by their being stationary, is lost on

* Inserted in the fourth volume of the second series of the Repertory of Arts, p. 81.

the other hand by the necessity of giving a rotatory motion to the rope, and the greater difficulty of coiling it away; more particularly in large cordage in which the advantage lies with the planetary method.

VIII. The principles on which the manufacture of cordage might be improved, were, as related, already attained; but the modes of carrying them into effect with such facility as to render them generally useful, were not yet effected, when Mr. Chapman, in March 1798, obtained another Patent* for "laying, twisting, or making ropes and strands of ropes, and of coiling up such ropes and strands of ropes during the process of making." The invention consisted first in tarring the yarns in such a manner as to cause them all to wind up singly, as they should come from the tar-kettle; which facilitated the process of manufacturing rope in any way which gave all the yarns a full bearing in the strand. Secondly, it consisted in making the strand separately in two distinct ways by house-machinery, viz. either by having the yarns, on separate reels, fixed on a platform, supported on or in the revolving shaft, or frame, by which, after the yarns were concentred to a focal point, the strand was to be twisted, and from thence progressively drawn forward, and wound up as made *by machinery in a stationary position*; or by fixing the reels in stationary frames, and conducting the yarns separately to one general focus, over or opposite to *a revolving shaft or frame, in which the strand has to be wound up as made, and which, as a most essential part of the invention,* CONTAINED *the machinery which was to haul forward the yarns composing the strand.* These two (and a combination of them) included all the possible methods by which a strand could be made, without a rope-ground, so as to give each yarn a different length in the strand according to its distance from the centre.

* The specification of a Patent which Mr. Chapman obtained for Scotland, containing the substance of this and the preceding Patent, is published in the 9th vol. of the first series of the Repertory of Arts.

Something like the latter had been used to wind up, with a small twist, a number of yarns, preparatory to their being made into a strand; but its hauling forward machinery consisted in two rollers on a *stationary and separate* frame, close to the opening in the top of the axis of the revolving shaft; which twisted the yarns prepared for a strand, and contained the reel on which it was wound up. The two rollers which compressed and brought forward the yarns, necessarily drew them out of the same length, and prevented the yarns being twisted into a mass in any other way than on the old defective principle.

On obtaining this Patent, a machine that received its motion from a crank, and which was erected in a warehouse in Newcastle, for making ropes of five inches girt, and under, was tried, and a few ropes for experiment, and some large strands, were made; which latter, on being broken by suspended weights, gave so favourable a result, when compared with common-made strands of the same number of yarns, in the presence of a public meeting, assembled on August 2d, 1798, for the purpose of seeing the experiments, as to prove to conviction the superiority of the new manufacture. These strands contained one hundred and forty-four threads each. The common-made ones were shortened, or set up, one fifth of the length of the yarns according to the usual practice; and those laid after the new system had the same spiral or angle of twist in their outside yarns; and, on breaking, gave a result exceeding in strength rather more than three to one. This disparity is far from what exists when these strands are made into ropes; which probably may arise from the puckered yarns in the common-made strands being more prevented from drawing out, from the strong compressure of the strands against each other, when the rope which they compose is stretched. The result had so convincing an effect, that, soon after the exhibition of the experiments, Messrs. Hood, Errington, and Co. of Newcastle, agreed with Mr. Chapman to practise his method of making ropes after the mode that will shortly be described, and were the first

manufacturers of cordage on the new principle on an easily practicable method.

Another company soon afterwards entered into a similar agreement for the use of a machine to make strands.

This Patent contained a new invention, which required little more apparatus than is used in common roperies; viz. so many reels (each containing one or more yarns) as were necessary for three strands, were to be fixed at the head of the ropery, and their yarns led in three separate divisions to the foreboard; where the yarns, after individually going through perforated plates, passed through three compressible openings, called press-blocks, where they received any determinate degree of compressure and resistance.

These separate masses of yarn were, after passing through the press-blocks, to be attached to three hooks on a sledge, which might be turned by men as usual, "the only remaining difference consisting in the sledge being drawn progressively backwards, as the strands were making, which, amongst other methods, was to be done by a rope to a capstan, moved either by a horse or men."—This Patent, of course, comprehended the method now used in the King's yards, which took place subsequently.

IX. Mr. Balfour obtained his second Patent, dated the month after the preceding, viz. on the 3d of May 1798, for "improvements in the operation or working part of a machine formerly invented by him for making and manufacturing ropes and cordage," which contained nothing more than the last-described method, except mentioning circumstantially *his* manner of turning the strand hooks, and of heaving the sledge backwards, which was also by a capstan; and like the one to which it is compared, as not differing, it leaves the backward motion of the sledge and the twisting of the strands, to be regulated by the eye of the workmen; which, of course, must be defective, from having so uncertain a criterion.—Mr. Balfour had previously tried in the King's yards his

first method, and that failing of the desired success, he effected the latter, for which he received several thousand pounds from the Navy Board as a reward.

X. Mr. Chapman seeing the imperfection of this first invention of the backward motion of the sledge, which is the most simple method of forming strands on a perfect principle, conceived the idea of so regulating the motion of the sledge backwards, that it must at all times travel neither more nor less than the speed predetermined; so that for every revolution of strand, the sledge should retire precisely the length of axis assigned to it, and of course occasion the twist to be uniformly regular; the close approximation to which is an object of importance in the acquisition of strength.

He therefore, on November 8, 1798, took out a Patent for effecting that purpose, and for some other circumstances of inferior moment*. The first object, that of uniformity of twist, he attained in the following manner; viz. by stretching a rope which he called a ground-rope, the whole length of the ropery, and upon the floor of it. This rope was passed in the form of the capital letter S, partially round two or more grooved wheels, with horizontal axes, fixed with other apparatus on the common machine for making ropes, technically called a sledge; but which, for this purpose, is fitted with wheels to travel on a rail-road.—The grooved wheels press against each other to bind the rope, and have upon their axes tooth wheels, connecting them with each other, and finally with the hooks for turning the strands; which, in this instance, are all turned by one great crank intervening between the hooks, and the wheels appropriated to the backward motion, and connected with the ground-rope.—Thus, when the hooks were turned by the crank, the sledge was also drawn backwards by the turning of the grooved wheels, which received any determinate motion to

* The specification of this Patent will appear in an early number of the Repertory of Arts, and engravings of the drawings are given in plate II. at the end of this work.

that of the strand hooks by means of changeable wheels easily taken off and on.

In the preceding instance, the labour of the men is relieved by a rope leading from the sledge to a horse capstan, at the foot of the ropery. In consequence of the ground-rope (which is capable either of drawing the sledge forward, or retarding its motion) the horse cannot draw the sledge faster than it ought to move: but his spare power is given in aid of twisting the strands through the intervention of the wheels, which connect that operation with the backward motion.

Under these simple and efficacious methods, three considerable roperies on the river Tyne are now working under license from Mr. Chapman; the expense of fitting up a ropery with all the apparatus being done by contract for five hundred and sixty pounds.

The first ropery fitted out on this principle, so easily adapted to all roperies, was that of Messrs. Hood, Errington, and Co. already spoken of (now Messrs. Hood, Winship, and Co.), who, in October 1798, commenced manufacturing rope on the new principle, and which they have ever since continued: but such was the difficulty of inducing ship-owners to make trial of the new manufacture, that it was not until May 1799, that any cables were applied for. On the 7th of that month, the first cable that was ever made on the perfected principle of all the yarns bearing fairly in the strand on its near approach to the stress that would break it, was laid for Mr. S. Chapman, for the Cyrus, of Sunderland, and is yet in use. Some time afterwards a cable, which was only of ten inches and a quarter girt, was sent over-land to Whitehaven; and had a fair trial in Dublin bay, where it was bent to a new fifteen-inch cable, made in Dublin for lifting a vessel that was sunk, and it broke the fifteen-inch cable, which proved the vast superiority of the one over the other.—This indeed exceeded what experience, resulting from the breaking of ropes of different girts by absolute weight, has given; therefore part of the difference consisted in the one cable being made from staple hemp, whilst the other must have been from inferior.

The comparative advantage of the new manufacture over the old, evidently depends on the number of yarns in a strand; if three only, the old mode is obviously as good as the new, and no material advantage takes place until the number of yarns exceeds ten or twelve.

The following table, deduced from experiments in breaking ropes on a machine, with one end of the rope attached to a great steelyard *, will give a general idea of the utility of the improved manufacture.—In this table the strength of ropes on the new principle is rather under-rated; when all its relative twists are duly proportioned.

TABLE.

COMPARATIVE STRENGTH OF

SHROUDS.		CABLES.	
Common made.	On improved Principle.	Common made.	On improved Principle.
Girt.		Girt.	
Inches.	Inches.	Inches.	Inches.
3½	3	7	5⅞
4	3¼	8	6½
4½	3¾	9	7⅛
5	4	10	8⅛
5½	4½	11	8⅞
6	4¾	12	9½
6½	5	13	10⅛
7	5¼	14	10⅝
7½	5¾	15	11¼
8	6	16	11⅞
8½	6¼	17	12¾
9	6½	18	13
9½	6¾	19	13½
10	7	20	14⅛

* Any other method than attaching the rope to a steelyard, or scale-beam, will, on account of the friction of the machinery intervening between the rope and the weights, give a result beyond the actual strength of the rope broken.

These ideas are confirmed by some observations that have been published in the second volume of the "Retrospect of Philosophical, &c. Discoveries*."

Government have their cables on the improved principle, made of the same size as by the old method; and therefore have the full advantage of increased strength; but, in the merchant service, it is usual to have them of mean strength between those compared in the preceding table.

Besides the manner of making ropes by a sledge, as already described, the specification contains a method of spinning by women or children in a stationary position, which, in practice, did not prove worthy of adoption; and likewise a method of making ropes complete at one operation; viz. by dividing the strand machine into two parts, the *upper* putting in the twist invented by Mr. Balfour; and the *lower* division moving so much faster, as to cause the additional twist, first made known to the public by Mr. Huddart, to be superinduced, without which the rope would be imperfect. The mode thus described would undoubtedly answer the end, but I prefer its being attained at two operations *with stationary reels*, as being attended with less trouble.

XI. November 17th, 1798, Mr. John Curr, of Sheffield, obtained a Patent for "a method of forming and making a flat rope, intended to be used in drawing coals and other minerals and water out of mines of any kind."—His specification† says, "the said flat ropes may be formed by connecting two or more small ropes sideways together, by sewing or stitching, lapping, or interlacing with thread or small ropes, &c."—He then describes his machine for stitching them together.

It was found necessary to make the constituent ropes alternately of a right hand and left hand twist, to keep the flat rope in a quiescent state; and, in this form, composed of four small shroud-laid ropes, they have now been

* A new work published quarterly, professing to give an account of all new facts and discoveries in the useful arts, with criticisms on their merits and defects.

† Published in the 10th vol. of the first series of the Repertory of Arts.

used some years, in the midland counties, for drawing of coals. These ropes wind up in a spiral upon themselves.

XII. On April 30, 1799, Mr. Daniel Balfour obtained a third Patent; viz. for his invention "for simplifying and facilitating his process of making ropes according to his preceding Patent."

He recommends any number of yarns, not exceeding four, to be wound on each reel; and describes a method of winding them to cause them to come off equally. In the King's yards they follow this method; but, let the yarns be wound ever so equally on the reel, they will afterwards, between the reel and their point of union in the strand, assume different lengths, accordingly as they chance to fall in more or less distant from the centre: therefore, whilst some of the yarns from each reel are quite tight, others soon become so slack as to require to be cut and knotted; and, with every care, it is impossible to prevent many yarns going slack into the strand, whilst others are strained;—of course there can be no perfection but by each yarn having its separate reel; unless the number of yarns upon each reel be combined by a slight twist, which would be similar to the first part of Mr. Mitchel's process, in his Patent of April 30, 1799—*Vide* No. XX.

The remainder of the specification consists principally in variations of no great importance on the methods proposed in his last Patent, excepting the spinning of tarred hemp, which he claims; but the difficulty of the process, has no doubt prevented its ever being carried into effect.

Another part of his invention has been useful by enabling the spinners to avoid the loss of time in returning;—for this purpose he has a wheel at each end of the rope-ground; so that when the men have spun the length of the ground, they have only to face about, and spin back again.—In this case, boys take the threads off the hooks, and lay them at length on one side. Spinners, by these means, are enabled to spin more threads, which is an object where they are difficult to be obtained; but the charge per thread, including the labour of the boys, will, I presume, be nearly the same, or perhaps more.

XIII. Mr. William Chapman having, by his last-recited Patent, invented an accurate method of proportioning the backward motion of the sledge to any pre-determined twist of strand, conceived that it would be a great improvement to apply the power of a steam-engine to such locomotive machinery as is necessary in rope-grounds; and having discovered an easy method, he, conjointly with Mr. Edward W. Chapman, on July 26, 1799, took out a Patent for it and other inventions, under the title of "a method or methods of making cords and ropes and cordage, both tarred and untarred, from the spinning of the yarn inclusive, to the finishing of the rope or cordage *."—This new invention consisted of many parts;—the first was an improvement in spinning the yarn; which, in the usual mode of spinning with the hemp round the waist, has all the imperfection of the mode of forming strands according to Mr. Balfour's method;—each fibre of hemp being drawn out of different lengths into the yarn, accordingly as its distance from the centre required, similarly to that of the respective yarns forming a strand by the method mentioned; which is immediately apparent on untwisting a piece of yarn, as the outward fibres will become slack; therefore, as the yarns composing a strand are necessarily untwisted by the counter-twist of the strand when laid, it followed that the remedy of this imperfection was a desideratum.

Mr. Huddart, in his Patent of 1793, had, as already related, retained the strength of the yarns by giving each separate yarn a counter-twist to the strand, during the operation of its being made. This method was capable of producing the effect intended, but was too complicated, and required too much room to be carried into effect on an extensive scale.

The method now invented was to effect the end, in the act of spinning, which was done by women and children in a stationary position, one to each

* The specification of this Patent will shortly be published in the Repertory of Arts, and engravings of the drawings are given in plate III. at the end of this work.

spindle and bobbin. The double twist was effected by dividing the spindle, and giving it two separate motions, or done by a second process. The effect of superior strength was obtained, as will appear by the following experiments made before Mr. Watson Fenwick, master ropemaker to His Majesty's yards at Chatham: but as no higher price could be obtained for cordage made of such yarn, and it was attended with the cost and repairs of machinery, and would require many spinning frames for a large establishment, it was consequently laid aside.

EXPERIMENTS.

On April 29, 1801, Mr. Fenwick spun a thread of yarn, *at Willington ropery*, of the usual size, from the common wheel, and another on the double spindles; the first spindle putting in ten turns per foot, as drawn from about his waist, and the second spindle six additional turns. A piece of each was then broken in the state in which it was spun, which is shewn in column No. 1. Another piece of each was then broken, after taking out two turns per foot, the strength of which appears in column No. 2.

	No. 1. lb.	No. 2. lb.
Common spun	135	100
Machine spun	205	220

The deduction is obvious, as the machine-spun yarn of the two twists was not only the strongest in its original state, but gained strength, by twists being taken out of it as must be done in making them into a strand, whilst the other, by the same process, lost strength.

On the mean of four pieces of machine yarn of the usual size of eighteen threads to the strand of a three-inch rope, which were tried subsequently to the preceding,

	Lb.
The yarn, with the twist it had from the machine, broke with . . .	194
The same yarn, with three turns per foot, taken out	235

Hand-spun yarn of the same size, and spun from the same parcel of hemp, which was remarkably good, bore as under: Lb.

As spun	175
With three turns per foot taken out	128

Although never yet practised, some portion of the effect of the double twist may be obtained in the common process of spinning, by giving the whirls whilst the spinners go backwards as slow a turn as the men can admit of without the threads breaking; and causing them, when the threads are spun to their full length, to continue until the additional twist be put in, or leaving a boy for that purpose to attend every four threads (the number usually wound up together), and follow them in.

It has already been stated, that strands, made on the perfect principle, compared with those after the old method, possess individually as strands a superiority of strength of upwards of three to one, when each contained one hundred and forty-four threads; but, when made into ropes, that disparity is reduced to considerably less than two to one.

It also follows, that in yarns this individual superiority is reduced when made into strands.

Hand-spun yarns are rarely spun uniformly, and when broken individually, necessarily give way in their weakest parts, though only *a small portion of their length*; but, when combined in a strand, they then exert the average strength of all their parts; so that, on experiment, a well-made strand has been found to bear more than the sum of the individual strength of pieces of two feet length of the same yarns, although theoretically the strand should be considerably weaker.

The most easily available parts of the improvements stated in the specification of this Patent were,

1st, The application of an endless rope (moved with considerable speed, and reaching from end to end of the rope-ground) to machinery in any part,

whether stationary; or changing position as ropers' sledges necessarily must. This was effected by passing the bight of the endless rope round suitable grooved wheels on the sledges, and thus giving motion to their machinery.

2d, Correspondent machinery at the head of the ropery, to the axes of which the ends of the strands were attached during the making of the rope, was so contrived that the axes possessed the capability of varying their respective revolutions, during the act of moving, so as to admit of any of the strands being tempered and brought to a fair bearing.

By these means all ropes, from a small size to the largest, are capable of being made, either upon the old or new principle, without the aid of more men than necessary to attend the machinery, and take out and put in the stake-heads, as the top (or implement round which the strands twist themselves into a rope) progressively moves up the rope-ground, which, like the rest of the moveable machinery, it does upon a rail-way. By these simple means, many large *men of war's cables* were made in Messrs. William Chapman and Co.'s rope-ground, at Willington, on the river Tyne; *for which purpose* the works were constructed on a more enlarged scale than the trade of Newcastle requires.

The advantage of this process is apparent;—first, As each respective motion and comparative revolution of strand and rope, is predetermined and fixed by changes of wheels, every part of the work is conducted in a uniform manner, and not liable to mistake, as tables are made out, stating what wheels are to be used;—and 2d, In place of two hundred men, which are usually employed in closing a twenty-one inch cable, fourteen are only required, and they can also coil it away with the help of the steam-engine, which is only of eight horse power.

This plan is now in use in two other large roperies on the river Tyne.

In the present Patent, there is described an invention to make cordage on the new principle at one operation: viz. by dividing the strand shafts into two parts; the upper, which supports the platform, holding the ne-

cessary number of reels of yarn, puts in the twist according to the principle of Mr. Balfour; and the lower part goes so much faster, as to give the additional twist invented by Mr. Huddart. The rope was to be laid at the same time, by the revolution of its separate frame, in which it was to be hauled forward, and wound up as made.

XIV. On July 22, 1799, Mr. James Mitchel, of Poplar, obtained a Patent for "a method of manufacturing cables, hawsers, or shroud-laid ropes, and other cordage, on a scientific principle."—Mr. Mitchel's method was ingenious, but not peculiarly entitled to the definition he gave it.

The defect of the common principle of making cordage has been stated not to exist when the strands are each formed of three yarns only, and to be very little with ten or twelve yarns; but from thence it very sensibly increases with the number of yarns, or rather with the number of concentric circles they form round the axis of the strand, though not precisely in that ratio; as, when the strands become large, two concentric circles will, from the elasticity of the rope-yarn, act together with a larger portion of their maximum strength. I now speak of hemp rope-yarn—*Sun* is less elastic, or scarcely so at all; and therefore ropes made of that description of hemp, will be more benefited by the new process: and on the same principle, ropes made of coire (the inner rind of the palm-tree), which is very elastic, are improved in a much less degree.

Mr. Mitchel's system has the merit of retarding the ill effects arising from an increased number of concentric circles; because, previously to forming a strand, he slightly twisted a small number of yarns together, and these slightly twisted sets of yarns were united in the strand as so many single yarns: for instance, if a strand should require sixty yarns, which according to the common process would lose much strength when combined in a strand, Mr. Mitchel would previously have formed them into slightly twisted divisions of five or six yarns, ten to twelve of which

primary combinations would form a strand of sixty yarns:—and as it has already been said, that the process on the principles brought to the public attention by Messrs. Balfour and Huddart possesses no material advantage in strands of ten or twelve yarns; it follows, that considerable advantage over the common process may in middle-sized ropes be derived from Mr. Mitchel's method.

It however necessarily increases the number of yarns exposed to external injury, because in the outside shell, nearly every yarn of each combination must be exposed to be worn, wherever the twist throws it outwards*.

XV. Mr. John Grimshaw, of the township of Bishop Wearmouth (who succeeded Mr. John Fothergill, and constructed the works at Southwick), obtained, in August 1799, a Patent for an "invention of certain improvements in the methods of manufacturing ropes and cordage," consisting, 1st, In the dressing or splitting of hemp preparatory to spinning;—2d, In winding up the yarns;—3d, In preparing the yarns for tarring;—4th, In laying or forming the ropes or cordage, and the strands thereof.

The chief part of the first invention consists in conducting to the rotative heckles the heads of hemp when spread out, through conical fluted rollers, shaped as truncated cones, by which means the hemp appears to be very equally mixed.

His second and third parts consist in winding any given number of yarns preparatory to tarring, on a long cylindric barrel, which contains the whole length to be tarred at one time; previously to which it is drawn progressively from the cylinder, and coiled away in a revolving tub, or on a revolving platform, by which means the mass of yarns are twisted together, and prepared to go through the tar-kettle; from which they are again

* The specification of Mr. Mitchel's Patent has been published in the Repertory of Arts, vol. xi. of the first series.

coiled away in a tub, or on a platform, with similar revolutions the contrary way, so as to be prepared for separating.

The fourth part of this invention is principally in the addition of a conical block of wood, technically called a top, which revolves with the central motion of the rope machine; and in its grooves, the strands come to the point where they unite into a rope; which, as progressively made, is drawn away by a *stationary* cylindric barrel, of such length of axis as will contain without doubling the whole length of rope to be made (the cylinder, of course, must receive its motion from external machinery). On this he concludes by saying, " and which cylinder and its apparatus above described, I also apply in a similar manner for making or forming the strands, in drawing them separately from the bobbins or reels, during the operation of receiving the twists, and thereby forming the same, and measuring their lengths at the same time, without the necessity of extending the yarns on a rope-ground."

The method, so far as Mr. Grimshaw has described it, would do nothing more than wind up the yarns without twisting them, and consequently would not make a strand.

To produce that end, it would require the addition of a revolving platform (described in the Patent No. VIII.), containing the necessary number of reels; the yarns from which would at their point of union into the strand be drawn off, of due lengths proportioned to their distance from the centre, and consequently may finally form a rope of the improved construction;—or otherwise the desired effect must be produced by leaving the yarn reels in stationary positions, *as is implied* by this specification: but then this described cylinder must no longer be stationary, as implied to be, nor can it wind up the strand without the aid of *some internal machinery moving round with it*, as described to be an essential part of the invention of the aforesaid Patent No. VIII. As the works at Southwick are carried on in a house, and they keep secret their mode of making strands, I cannot inform the public of the process adopted by the proprietors of that manufactory.

XVI. On August 20, 1799, Mr. Huddart took out a Patent, for "an improved method of registering or forming the strands in the machinery for manufacturing cordage *."

Mr. Huddart and his partners constructed this machinery on a very extensive scale, at their ropery at Limehouse; and on the 21st of April 1800, made their first cable, which was one of twenty inches girt. A part of this cable was kept for experiments, which were made before Admiral Gambier, and several of the East India Directors; and satisfactorily proved the decided superiority of cordage of the new manufacture over the old.

The only part of the process by the power of a steam-engine, is the formation of the shroud-strand. The rest is carried forward by the power of men as usual.

XVII. On or about July 1, 1800, Mr. Huddart took out a third Patent, viz. "for certain improvements in tarring and manufacturing cordage †."

He says much expense is attached to winding the tarred yarn on bobbins; and that the tar, when the rope is laid in cold weather, is not sufficiently incorporated amongst the yarns to render them compact for durability, whether registered, or laid in the common way. In order to obviate these inconveniencies, he has invented a method of registering the strands of ropes, during the operation of tarring the yarns, which may be effected in the following way: viz. the kettle should be covered to retain the evaporated matter, which, if passed off, renders the yarn too pitchy.

A thermometer should be used to shew the heat of the tar, which, if too high, will tender the yarns, which has too often been the case in the

* The specification of this Patent was published in the Repertory of Arts, vol. xii. first series.

† The specification of this Patent may be seen in the 14th volume of the first series of the Repertory of Arts.

common method of tarring. Mr. Huddart has not said to what heat. The common practice of ropers is to bring the tar to a gentle boil, so as to throw scum upon a considerable and connected portion of its surface, before and during their passing the yarn through it.

This circumstance takes place about the heat of boiling water, and continues with some enlargement of the surface, covered with scum up to 250° of Fahrenheit (without boiling over), which is considerably too high.

Yarn at all times is injured by passing through hot tar, and often much beyond its usual deterioration. This takes place in the common practice of tarring by hank, viz. three and four hundred yarns slightly twisted, so as to prevent their entangling. In this mode, the men at the tar-kettle frequently coil into it a large quantity, part of which must of course remain a long time in the boiling tar. Messrs. Huddart and Co.'s cordage made in the manner he describes, is remarkably compact and firm; and whatever effect may be derived from that circumstance, resulting from the strands being made whilst hot, must be long since experienced. Some degree of heat is requisite to cause the yarns to run smoothly through the tube, where they concentre in a strand: for which purpose, at Willington ropery, the press-blocks, or compressible tubes, are placed on a square hollow tube of cast iron, which is heated by steam, to which method Messrs. William Chapman and Co. were led from experiencing much difficulty in commencing the backward motion of the sledge in cold weather, and from seeing that the strand came forward very easily, so soon as the tube it passed through was heated by the friction of the strand.

XVIII. July 16, 1801, Mr. William Hoard, of obtained a Patent for "a portable machine for manufacturing ropes and cordage of any length in a short space, particularly adapted for shipping." This machine consists of separate reels, one containing the full length and num-

ber of yarns for a strand, from which reel they are drawn out to such distance, as the two reels can conveniently be placed asunder, and are attached to the other which is then empty, one of the reels being in a sledge, or moveable frame. The process then begins by twisting the intermediate length of strand, until the reels have approached to each other the usual proportionate space, viz. one-fifth. The length of strand thus made, is then wound up on the second described reel, and so much let off from the first reel, as to admit of their being at their greatest distance asunder, which process is necessarily continued until the whole strand be made, and wound up on the second reel.

Lastly, three strands thus made, have their ends united to a fourth reel placed opposite to them at its greatest convenient distance. By these four reels, the process of making the rope is carried on similarly to that of making a strand, except in the use of a top to regulate the progress of the twist of the rope, in its approach to the three strand reels.

XIX. In 1801, Mr. Archibald Thompson, of Plough Court, Lombard Street, took out a Patent for "certain new or improved machinery, for the purpose of spinning rope-yarn and sail-cloth yarn, and for laying and making ropes and cordage." Mr. Thompson's invention includes the whole process of spinning, tarring, and laying the cordage. Preparatory to spinning, he draws out the hemp into a long sliver, by different sets of chain heckles, moving with progressively greater speed; and in the end the sliver is spun by a spindle with its plyer and bobbin into a thread. The threads remain wound up on their bobbins, until wanted to be made into a rope, tarred or untarred. The bobbins are then, according to the number of yarns wanted in a strand, placed so as to form two circles of the same diameter, round an open cylinder consisting of three hoops or rings, distant from each other the length of a bobbin, and placed near to one end of a long horizontal axis; and, if the rope be to be tarred, the yarns are led

through a ring of a few inches diameter, near that end of the described open cylinder, which has the spare length of axis projecting from it. The yarns are then diverged in different degrees, so as to form, when passed longitudinally through an open cylindric frame of several feet in length, so many different concentric circles round the axis mentioned, as there are different shells (or concentric coats) of yarns in the strand; and from the further extremity of this last mentioned cylindric frame, the yarns are concentred to one focus at the extremity of the axis, which is there concave, and has an opening through which the yarns pass to the machine which is to twist them into a strand, and draw them forward to be coiled up within itself. At the focal point described, there are nippers to express the tar from the yarns, which is put into them in the following manner: viz. the last mentioned open cylinder, between the ring from which the yarns enter to it, and the perforation of the axis where they concentre and quit it, lies over a tar-kettle, and has a portion of its lower half immersed in the tar, just so far as to imbue either the whole or any portion of the yarns with tar, as may be deemed expedient. This cylinder must, of course, turn round with such convenient degree of speed as not to let the yarns be drawn off the cylinder before it comes in their rotation to pass through the tar. When the full length of strand is made, the twist of which is principally given by the revolution of the frame, in which it is progressively wound up during the process of making, the yarns are cut off; and three of these strands, from so many stationary strand frames (each of which has performed the operation last described, revolving only round its own separate axis), are concentred together, and pass through the axis of one end of a rotatory frame, which twists them into a rope, and coils it up, progressively as made, upon a barrel within the frame; being similar to the invention No. VII. in dispensing with the planetary revolution of the strand frames.

XX. About the close of 1801, Mr. Cutting, of the United States, and their consul at Calais, invented a method of making lines and ropes.

His process was ingenious, but upon the principle of almost all that have been described, viz. by the strand frames forming a planetary revolution round the central part, which twisted the rope.

XXI. In January 1802, Mr. William Chapman obtained a Patent for his "Invention of the application of certain substances, either separately or combined, as a preservative for cordage."

Mr. Chapman was led to this improvement by a knowledge that rope-yarn loses a considerable portion of its strength in the act of passing through the tar-kettle, and that tarred rope loses *progressively* more of its strength, even in cold climates, and very rapidly in hot ones, so that, in three years, it is scarcely fit for use. The requisite properties of a preservative for cordage against the injuries arising from transitions to moisture and dryness, and from the heat of a tropical climate, appear to be,

1st, That the preserving substance should not be soluble in water.

2d, That it should not become rigid by length of time, as this circumstance would frequently occasion the rope to be weakened by sudden bendings, which often takes place in the bolt-ropes of sails, to the loss of the sails, and if on a lee-shore, to that of the vessel itself.

3d, That it should not contain either acid or essential oil, capable of being disengaged by heat; as either of these would occasion that species of destruction of cordage known by the name of the dry rot. If tar be exposed to these tests, it will be found that it contains a considerable portion of mucilage soluble in water; that it does not prevent cordage from becoming rigid; and, finally, that it contains properties which either occasion the dry rot, or do not prevent it.

The present invention tends to remedy these evils by the following process, viz.

1st, By boiling the tar in water one or more times, each of which extracts a portion of its superabundant acid, and its mucilage, which contains a disengaged acid.

2d, By continuing these processes until the tar has thrown off a larger portion of its essential oil, and becomes more pitchy than usual; and, finally, by restoring the requisite plasticity through the addition of substances less injurious and less volatile, and therefore more continuous, viz. by the addition of suet, tallow, animal oils, or *suitable* expressed oils.

A portion of animal oil is soluble in water and apt to turn mouldy; but this part is got rid of by mixing the oil with the tar previously to its being boiled in water.—Gelatin, gluten, and mucilage, are all of them putrescible when subjected to moisture and heat, and therefore must be improper accompaniments to any substance liable to the same cause of decay.

How far the desired ends may be acquired by the means proposed, may be judged of by the following experiments and observations; viz.

Report of Mr. William Allen, Lecturer on Chemistry at Guy's Hospital, on the Advantages of using certain Preparations of Tar in Cordage, invented by Mr. William Chapman, of Newcastle-upon-Tyne.

"Common tar unprepared, contains a quantity of vegetable acid; and apprehending that this acid might injure the texture of cordage, the following experiment was made:—A piece of twine, which, by previous trial, was found capable of supporting sixty-one pounds without breaking, was immersed in vegetable acid, and, after forty-six hours, it was so much injured that it broke with a weight of less than sixteen pounds. A piece of the same twine was immersed for forty-six hours in the essential oil, which came over in distillation from the jar; and, although it had suffered no diminution of strength at the termination of its immersion, yet, after being exposed three days to the air, it was only capable of bearing thirty-one pounds.

"The Stockholm tar used in these experiments, was found to contain about seven per cent. of vegetable mucilage, capable of being converted into acid

in a hot climate, when the cordage is immersed in water; the tar also contained as much real acid as there is in *an equal measure of common vinegar*; but by repeatedly boiling the tar in water, according to the method prescribed, it is freed from its acid and mucilage, and may be employed in the manufacture of cordage with great advantage, in the place of common tar. Also, if the prepared tar be boiled down so much further as to deprive it of that portion of its essential oil, which it is found necessary to retain to prevent tarred cordage being too rigid, and the place of the essential oil be supplied with a due portion of fixed or expressed oil, it is probable that those injuries will be done away, which arise from the action of essential oil on the fibres of the hemp, and from the rigidity of cordage, experienced in vessels returning to cold from hot climates where the essential oil is considerably thrown off. WILLIAM ALLEN."

Plough Court, Lombard Street, 24th of 7 Mo. 1802.

On August the 10th, 1802, three pieces of rope, of twelve threads in each strand, were made at Willington ropery;—the first was a white rope, the second washed tarred yarn, and the third common tarred; a part of each was then taken to the breaking machine, and another part was immersed in water for about three months, and afterwards taken to a foundry stove, which was very warm, perhaps about 130° of Fahrenheit, but not ascertained; they remained there about as long, and afterwards were brought to Willington ropery, where they were laid aside on account of Mr. Chapman's absence from Newcastle. No experiment was therefore made until November 3d, 1803, the results of which are as under:

	Weights broke with on Aug. 10, 1802.	Weights broke with on Nov. 3, 1803.	Proportion of original Strength, the latter one hundred.
White rope	Cwt. 33 . 4	Cwt. 1 . 9	5 . 7
Washed tarred rope .	29 . 1	12 . 35	43 . 8 per Cent.
Common tarred rope .	22 . 2	7 . 35	33 . 0

Both the tarred ropes were brittle, but the latter was much more so, and

crackled on bending; their disparity of strength, compared with regard to what they were originally, is as three to four. These experiments corroborated the opinion of Mr. Allen.

Notwithstanding these favourable circumstances were very generally made known, no one was inclined to give any preference to purified tar, but Mr. Renwick, of Newcastle, who is an owner in several West India ships, and knew from experience the inefficacy of tar as a preservative to cordage in hot climates. With a praiseworthy resolution to give it a fair trial, he fitted out the Indefatigable, a new vessel, designed for the West India trade, partly with cordage tarred in the common way, and the other part with purified tar.

This vessel was unfortunately lost on her first voyage, and of course no result was obtained. Therefore, as the process was attended with an addition of expense at that time of about one pound per ton, and no encouragement given, it was of consequence laid aside. It would now, from the increased price of tar and labour, cost more; but as the price of hemp and tar has risen to such a degree as to cause the longer duration of rope to be an object of greater national importance than ever, the full investigation of this subject is of proportionate moment.

By the last-recited experiment it appears, that rope-yarn not only receives less injury in *its process of tarring* through washed tar, but also suffers less afterwards, either from heat or time, than is lost by these causes when common tar is used.

That ropes receive injury both from the acid and essential oil contained in common tar, the following facts will prove; viz.

The inner end of cables receives most injury from the dry rot in the West Indies; and even in this climate the part always within board deteriorates the soonest, as has often been experienced by coasting vessels when they have gone into a roadstead in boisterous weather, and come to an anchor with what they supposed to be their best cable, because it had been little used. The result has several times been, that before the vessel has been brought

up, the cable relied on has parted; and then, on letting go their working cable, though considerably worn, it has rode out the gale.

From this it follows, that water extracts from tarred ropes some substance which is injurious; it cannot dissolve the resinous part, and therefore it must be the mucilage, which contains an acid which is injurious, according to Mr. Allen's experiments.

The following experiments, recently made, will shew the great injury which arises from the retention of that portion of essential oil which cannot be dispensed with in the common mode of tarring, and also that which takes place during its process.

In July 1807, three ropes were made each of the same yarn and same number, viz. seventeen in each strand.

No. 1 was a white rope.

No. 2 had its yarns passed through thick cold tar, properly expressed from it as with hot tar.

No. 3 had its yarns passed in the usual way, through boiling tar.

A portion of each was soon afterwards broken to ascertain their strength; and after exposing another portion of them for four months in a stove, the heat of which varied from 85° to 100° of Fahrenheit, they were again broken, and the following was the result of these trials:

	Cwt.		Cwt.
No. 1, broke with	45,72	Second trial with	38,97
2, . .	51,29	. . . .	26,40
3, . .	38,94	. . . .	25,07

By the above it appears, that the operation of passing through cold tar did not diminish the strength of the rope, but rather added to it, by causing the fibres of the yarn, and the yarns, in their combined mass, to adhere more strongly, and bear a strain more proportionate to the average strength of the individual parts; and that No. 3, in the process of tarring, lost nearly a fourth of its strength from the action of the acid and essential oil let loose

from the tar; but that, by an exposure to further heat, it deteriorated considerably, but in a far less proportion than the cordage made with cold tar; which clearly proves, that the latter suffered from the cold tar progressively disengaging the excess of the acid and essential oil which it had possessed in the state in which it was used.

The following experiments form an additional proof of what Duhamel and other French writers have asserted; viz. that tarred cordage loses strength in the process of tarring, and also from age, progressively afterwards.

Experiments on registered Ropes (viz. on the improved Principle) made of the same Yarns, and with seventeen Threads in each Strand.

			Cwt.	Comparative Strength.	Cwt.
1806,	Oct. 2,	White rope, girt 2.75 inches, broke with	75.	100.	9.9
	Oct. 24,	Tarred rope 2.8	55.	73.3	7.
1807,	May 8,	The same rope 2.8	41.4	55.2	5.3

The last column shews the number of cwts. borne at each time on each inch of the square of the girt of the rope.

Experiments on Ropes made of the same Yarns, and of nine in each Strand.

			Cwt.	Comparative Strength.
White rope, girt	1.7	inches, broke with	27.5	100
Tar and whale oil	1.85	. . . . .	22.5	83.7
Tar and tallow	1.8	. . . . .	17.5	63.6
Tar unpurified	1.7	. . . . .	15.95	57.7

The above trials were made on rope kept some time in a storehouse; but not having a memorandum of it by me, I cannot say how long. They nevertheless prove, that both whale oil and tallow have a good effect; but that tallow is far inferior to whale oil, which I conceive to be owing to the yarn being injured by the sebacic acid of the tallow which is thrown off by heat. Specimens of all these ropes were sent to the drying stove of an iron-foundry, where they remained too long, and the heat proved so great as to scorch

them all, so that they broke with only bending, which prevented any result being drawn as to the effect of tropical climates, except what arises from the preceding experiments on the same rope kept in store, which I conceive are sufficiently *conclusive as to the existence of benefit*, but not as to its proportion.

A course of further experiments are now proceeding on at Willington ropery, near Newcastle-upon-Tyne, which, if any new result arise, are intended to be laid before the public, accompanied with a recital of, and comments on, experiments which have been made in other countries, with a view to discover the means of prolonging the duration of cordage, which at all times has been a *desideratum*.

Some idea of the great national advantage that would result from the general adoption of the preceding invention for retarding the deterioration of tarred cordage, may be formed from the vast consumption of hemp in this country.

According to the imports given in Mr. Oddy's extensive work on European Commerce, it appears that the import of hemp into Great Britain, in 1799, was 37,619 tons, and the average import about 33,000 tons; therefore, as Ireland is not included, it may safely be assumed that at least 30,000 tons of hemp are annually wrought up into tarred cordage in the united kingdom.—From the preceding statement it appears, that twenty per cent. in point of strength and duration may fairly be expected to arise from the use of purified tar and whale oil; but, calling it only ten per cent. the annual saving would then be three thousand tons of hemp, which, at the present prices, would exceed 270,000*l.* of which the proportionate share to Government would be considerably more than one-third. Nearly 60,000 barrels of tar would be requisite for the manufacture of 30,000 tons of hemp into tarred cordage; on which there would be a proportionate saving; and, on the other hand, encouragement would be given to our fisheries from the increased consumption of whale oil.

XXII. In March 1802, a Patent was granted to Mr. James Mitchell the elder, and Mr. James Mitchell the younger, of the hamlet of Poplar and Blackwall, in the county of Middlesex, for "an improved method of manufacturing cables, hausers, and other cordage."

This Patent is for an improvement in the process invented by Mr. Mitchell, and granted to him by Patent in July 1799, which has already been described as the 14th invention.—The improvement consists in facilitating the process of combining, by a slight twist, his subdivisions of yarn, which form the constituent parts of his strands. They observe, that the twist of their subdivisions only shortens them from three to five fathoms in two hundred. Their process, after placing the sledge at its due distance from the head of the ropery, according to the length of rope to be made, is to attach as many subdivisions of yarns as are expedient, to as many hooks on the tackle-board (at the head of the ropery), and run them down in parallel lines over the stake-heads. This is performed by an instrument they call a bedder, which receives and compresses each subdivision separately, and recedes progressively towards the sledge; during which the subdivisions receive their twist from the hooks on the tackle-board. When arrived at the sledge, so many subdivisions as form a strand are attached to each hook, and the process goes forward in the ordinary way. After describing other methods of similar import, they say that, by means of tackle-boards with a sufficient number of holes, the spiral twist on the subdivisions "may be formed without rotation on the axis, by the simple process of thorough-putting the parts or subdivisions when coiled above the boards" (or platform over the tackle-board), and passing them through holes in the front board of the tackle-board, and drawing them onwards the distance required*.

* The specification of this Patent has been published in the second series of the Repertory, vol. viii. p. 241.

XXIII. In Oct. 1805, Mr. Huddart obtained a fourth Patent; viz. " for sundry new improvements in the manufacture of large cables and cordage in general."

Mr. Huddart " does not allege that any single thing in the drawing he refers to is in itself new, or that the particular combination of any part or parts thereof with any other part or parts thereof, is new, supposing the same to be separately taken and considered: but what he lays claim to " as his invention in these improvements, is the ultimate combination of these several parts, as forming one entire machine or system of machinery, tending to the laying of cables and cordage in a manner that is, to all substantial and essential purposes, new."—He observes that, in his machine, he uses some parts of Mr. Edmund Cartwright's cordelier (described as the invention No. II. in this Essay).

This machine consists of three strand frames, with a planetary motion, all revolving round one common axis, on which, and revolving with it, is fixed a roper's top, in the grooves of which the strands pass to their point of union, where they are twisted into a rope, which is drawn away as it is made by grooved wheels.

The machine is very similar to that patented by Mr. Fothergill, with improvements to it by Mr. Grimshaw, in August 1799, described as the inventions No. III. and No. XV. It only differs in the determinate motion being given to the delivery of the strands, so as to make them all of equal length; therefore the *grooved wheels* drawing forward the rope, have a slipping motion; viz. they are moved by an axis making more revolutions *than they do*, with which they are connected by a friction-strap, that may be brought to hold with any degree of tension suitable to the rope.

On the other hand, in the machines of Mr. Fothergill and Mr. Grimshaw, the determinate motion is given to the rope, and a retarding stress to the strands, which produces the same end, as the machinery of the strands is connected by a central wheel, which compels them all to deliver equally.

XXIV. In March 1806, Mr. John Curr, of Sheffield, took out a Patent for "a method different from any that has hitherto been invented or known, of spinning hemp for making of ropes or cordage."

His method of spinning consists in regulating the number of twists in the yarn, to the length moved by the spinner, so that they may elongate equally on being untwisted when made into a strand. To effect this desirable end, he has a barrel connected with the spinning-wheel, and consequently with the whirls by which the yarns are twisted. A cord is wound up on this barrel, which, when the spinners are going to set off, is attached to any one of them, and the rest are to keep pace with him. His speed is of course regulated by the unwinding of the cord from the barrel. He observes, that much of the strength of the strand of a rope depends on the equal elongation of the yarns, upon their being untwisted by the counter-twist of the strand. Mr. Curr's method will tend to produce that equality; but much must also depend on the threads being all spun of an equal and uniform thickness.

XXV. In August 1806, Mr. John Curr obtained a Patent for "a method of laying or twisting the yarns that compose a rope, by which method the yarns of a rope have a better and more equal bearing than they have in the common way." This Patent, like the one preceding for spinning yarns, is designed to give uniformity of twist in the rope: for this purpose, in laying the strands into a rope, he describes a method of regulating the motion of the roper's top; and also to give a regular motion to a perforated implement, which is to perform the office of Mr. Balfour's top-minor. (Vide Invention No. V.) A simple and accurate method of regulating the motion of the top is known to all ropers: viz. they mark the strands with chalk, where they cross any of the stake-heads, at a distance from the strand-hooks at the head of the ropery. The motion of the top is then given by the *after-turn* or twisting of the rope

behind it, and the foreman regulates its progress by the angle of the spiral, which he designs the strands to form round their common axis. If the chalked part of the strands advance towards the top, the men at the strand-hooks are directed to heave faster, because they have not put so much twist into the strands, as has been taken out of them by the twisting of the rope. On the other hand, if the chalked part recede from the top, it follows that more twist has been put into the strands than taken out by the rope, and the men at the hooks are directed to heave slower.

The twist put in at the strands, and taken out by the rope during the process of laying, is not, as has generally * been conceived, alike as to quantity: but the requisite turns of the strand are fewer than those of the rope, and the proportion of each is dependent on the obliquity of the spiral of the rope, the disparity increasing with the obliquity and following determinate laws, so that when the degree of obliquity of the twist is predetermined, and correspondent motions given to the rope, and to the strands, according to the invention No. X. where the whole process is carried on in a rope-walk, by machinery connected by an endless rope, and moved by a steam-engine, the man attendant at the top has, similarly to the common practice, the chalked part of the strands for his guide. If they recede from him, he lets the top move a little quicker, and if they advance towards him he holds back. Thus by both the last described means there is the utmost certainty of the twist of the strands remaining precisely the same in the rope, as they were before conjoined. It may, however, be altered afterwards, and without disadvantage, provided all the comparative twists be previously arranged accordingly. A knowledge of the causes and effects acquired by the experience arising from breaking, on a machine which will weigh their strength, a sufficient number of ropes formed under different proportions of relative twists throughout the whole

* The Author in the specification of his first Patent adopted this and other erroneous ideas, the falsity of which he discovered from experience and investigation.

process, must form the best basis for making cordage to the greatest perfection; and, as it depends on some regular combination of twists to produce that desired end, it follows that machinery duly arranged and connected, and capable of being set to a minute diversity, must have a decided advantage over any unconnected operations by hand.

XXVI. In August 1806, Mr. Ralph Walker, of Blackwall, engineer, obtained a Patent for "an improved method of making ropes or cordage of every dimension or size, by not only making all the yarn bear equally in the strand, and laying the strands uniformly in the rope; but also by making the rope or cordage from the yarns in the same operation."

In Mr. Walker's machine for making a rope at one operation, the frames which twist the strands similarly to the inventions No. I. III. IV. XV. XX. and XXIII. twist also the rope by means of a rotatory and planetary motion; and the chief difference is, that, in place of having all the yarns which are to compose the strand, wound up on one barrel, he has each yarn wound separately on its own bobbin, and placed in different ranges or tiers round an open cylinder, and all concentred to pass through a hollow axis at one of its extremities, where it is received on a pulley fixed on the frame, that performs the revolutions necessary to twist the strands into a rope, and on which the strand-frames perform their separate revolutions to twist the strands. From the pulleys last mentioned, each strand passes over another pulley nearer the common centre of the machine, to conduct it to a grooved block, which moves round with the main frame of the machine, on which the strand-frames perform their separate revolutions; and at their point of junction above the grooved block, they twist together into a rope, which is hauled away progressively, and wound up by suitable machinery.

The final effect of this machine will be to produce a rope on Mr. Balfour's principle, the peculiar circumstances of which have already been described under the Invention No. V.

The next point of Mr. Walker's plan is to make a strand separately, which he does in the following manner: viz. on an open cylindric strand-machine, that revolves round its own axis only, he places the necessary number of yarns on bobbins, and concentring them at one extremity of the machine, they are twisted into a strand, and drawn away by stationary machinery, similar to one of the modes described in the Invention No. VIII. When the strands are thus made, the barrels on which they are wound up, are placed on the necessary number of strand-frames, fixed on a revolving frame, so as to perform both the revolutions so often described, and the rope is drawn away as made. It is evident, that a rope made at twice, may have both the Balfour and the Huddart twist in its strands, and consequently all the yarns may be made to bear alike. A perfect rope may be made at one operation, by means of the last method described in the Invention No. XIII.; but the advantage in most instances is not equivalent to the inconvenience of having a great number of small reels, with rope-yarn revolving round a common axis. When the rope is made at twice, all these reels may be stationary, and of larger magnitude, so as not to require being so frequently changed or replenished. Mr. Walker points out means of passing the rope-yarns individually through the tar-kettle; and says, that he has used steam to heat the kettle, which he has found very useful, but does not claim it as an invention. This method will have the merit of preventing the tar from being over-heated, which undoubtedly is a desirable circumstance.

Mr. Walker concludes by observing, that the purport of his invention for laying of ropes has been produced by others; but, that he conceives the modes he has described "are different from, and simpler and better than any other yet discovered *."

* The specification and plan of the machinery are given in No. LX. of the 2d series of the Repertory.

XXVII. In June 1807, Mr. John Syeds, of Rotherhithe Wall, in the county of Surry, compass-maker, obtained a Patent for his "invented certain improvements in the construction of a machine for making rope or cordage, either thread or cable-laid, and in the mode of manufacturing the same."

The major part of the specification consists in the description of machinery fixed to a roper's sledge, which, from the casual diversity of the comparative motions of the powers *moving*, or *to be moved*, is designed to enable any given force to effect the desired end, in such portions of time as are consonant to their respective resistances. The final intention appears to be to make a rope in such a manner as that all the yarns should bear alike, which Mr. Syeds proposes to effect similarly to what is described as a part of the invention of Mr. Huddart, No. VI. by conducting all the yarns singly from the head of the ropery to a sledge placed at such a distance as shall be requisite for the designed length of strand. Opposite to the tackle-board of the sledge he places what Mr. Balfour has denominated a top-minor, but with some small deviation; in which is included a tube on the sledge side of the circle of holes, through which all the yarns are to be passed. He makes this machine a treble one to suit the three strand-hooks, so as to make all the strands at the same time. On turning the hooks, and consequently twisting the strands, the implement containing the three separate circles of holes, with each its tube in the rear of it, is to be moved forward in due progression to the head of the rope-ground.

The principal practical objection to the various machines of this description, is the difficulty of arranging and keeping separate all the yarns which compose a large strand.

XXVIII. On Oct. 30, 1807, Mr. William Chapman and Mr. Edward Walton Chapman, of Newcastle-upon-Tyne, obtained a Patent for "a

method or methods of making a belt, or flat band, for the purpose of drawing coals or other minerals up the pits or shafts of mines, and for raising of heavy articles in any situation whatever."

This invention consists in the combination of two or any greater number of strands of shroud-laid rope (viz. of primary strands composed of yarns twisted together), placed side by side, so as to form any determinate breadth of belt or flat band; and in a locomotive machine for stitching or rivetting them together whilst stretched at full length.

The primary strands composing the belt should, in general, be alternately twisted the contrary way to each other, and the yarns should be twisted the contrary way to the strands they compose. The peculiar advantages to be derived from these flat belts arise from the following circumstances; viz. " that the loss of strength, by the combination of these strands into a shroud-laid rope, is so considerable, that, exclusive of the reduction of length, from being twisted into a rope, which is usually about one-sixth, the *strength of two strands*, made in such a way as to make all the yarns bear an equal tension, or nearly so, will, when laid side by side, be nearly equal to *that of three such strands combined as a rope*; from which circumstance the chief advantage arises in forming the strands into belts, instead of making them into ropes." Finally, " all that this invention consists of is, the use of strands laid side by side, so as to acquire a strength which ropes used in this manner would not have." And also in the invention of " the truck or frame, with its apparatus for combining speedily and correctly together any requisite number of strands or other flexible substances laid side by side."

In the preceding extract from the specification, it appears that the invention rests on two points; one of which is, that the machine for uniting the strands together is *locomotive*, by which means strands, or other flexible substances, may be united together, whilst stretched at length under an equable stress, so as to take away their liability to disunion, from the breaking of the stitches or other fastenings, on receiving sudden jerks. The

other result of this invention is, that by it belts are formed on that principle which gives their immediately constituent parts the *greatest possible strength attainable from rope-yarns*; because a primary strand, made after the perfected manner so often described in this work, is of greater strength than would be produced by the same yarns extended straight by each other, and bound at intervals into a cylindric mass, called by seamen a salvagee; although Duhamel and other writers have supposed the latter to be the *strongest combination* of yarns, which it certainly was in large combinations before the recent improvements. At present it is not so, because rope-yarns are rarely or ever of uniform strength for any material length; and therefore, when acting individually, as in a salvagee, *each yarn must break in the weakest part*: whereas, in a strand on the perfect principle, the small portion of strength that is lost by the oblique direction of the outside shells of yarn, is much more than counterbalanced by the yarns binding each other, so as to prevent slipping; and consequently, by their acting with a force equal to the mean strength of each yarn, which, as the extent of the weak parts is in general but a small proportion of their whole length, will conjointly give a force considerably beyond the sum of the resistances of the weakest parts of each yarn. In fine, the utility of this invention chiefly rests on the superior strength derived from the novel combination of certain constituent parts of a well-known whole, which is perfect in itself; viz. a shroud-laid rope, but whose constituent parts are imperfect, and cannot be brought into use *singly*; because, without some further combination, they would untwist and become useless. The decrease of strength arising from three primary strands being twisted together into a hawser or shroud-laid rope, is much beyond what it ought to be theoretically. The reduction of strength should be similar to the decrease of length, which commonly is one-sixth or less. It is difficult to account satisfactorily for the excess of deterioration: therefore I shall do nothing more than proceed to state, that the same eccentricity takes place in the combination of three hawsers, or

shroud-laid ropes, when they are formed into a cable, as has been satisfactorily proved by breaking of many cables, from six to eight inches girt, and their strands separately, at Willington ropery.—The ropes were made after the manner of causing the yarns to bear equally; and the result of many trials was, that one of the cablets bore five per cent. more than twice the strength of one of its strands, and, in the other instances, they generally were from five to ten per cent. *deficient of twice the strength of one strand*; from which may be deduced the impolicy of continuing the old method of making the lower shrouds of large ships cabled, and sometimes the topmast shrouds; because, if made hawser-laid, *three-fourths of the weight of rope would be much stronger*. In the King's yards they have lately made their shrouds hawser-laid, at the suggestion of some of the members, and by order of the Navy Board: but as the above stated facts, as to *disparity of strength*, were, I presume, not known, no advantage would of course be taken of the reduction of *weight and bulk*, which, *in a nautical point of view*, as well as in an economical one, is of very essential moment. The practice of making large ropes cabled, was, as stated in the preceding part of this Essay, proper at the period in which it was adopted, and is so still in ropes made after the common process. The same cause, wherever the common method of making the strands is pursued, operates in favour of four-strand shrouds; because the number of yarns is reduced in each strand, which more than counterbalances the great uncertainty of the central core of these ropes ever bearing equally with the four strands winding round it.

XXIX. In the present scarcity of hemp, long wool has been suggested as a probable substitute to a small extent, and some few ropes of it have been exhibited. On one of these, which Sir Joseph Banks favoured me with for the purpose of ascertaining its probable utility, I made the following experiments. The first column shews the progressive weights borne by the rope; the second, the various lengths of a given portion of the rope, under each

respective strain; and the third column shews the lengths of the same portion after the weights were suffered to rest on the ground.

	Inches.	Inches.
Lightly stretched . . .	24	
Cwt. 1.65 . . .	26¼	
3.3 . . .	29 . .	27
3.85 . . .	31 . .	28
4.95 . . .	31¾ . .	29½
6.05 . . .	37 . .	32
7.15 . . .	37½	

With cwts. 7.7 the rope broke, and, by the sudden reaction, the marked part, originally of twenty-four inches length, returned to twenty-six and an half inches; although, in a preceding trial, it had lost so much of its elasticity as to stand at thirty-two inches.—The weights were put on by 7lb. at a time; but, from the circumstances under which I made the trial, I could not suspend the weights immediately from the woollen rope, which caused a further allowance to be necessary for friction, and which I ascertained to be sufficiently approximated by an addition of one-tenth.—I had previously conceived that elasticity was likely to be the most valuable property of a woollen rope; and therefore measures were taken to ascertain its proportionate reaction under different strains.

The girt of this rope unstretched was 1.8 inches, and it weighed in the proportion of 75lb. for 120 fathoms length.—A moderately compact untarred hempen rope, of the same size and length, would weigh 85lb.; and assuming it to carry only 8 cwt. for each inch in the square of its girt, it would have borne 27 cwt.; and if reduced in size so as to have been of equal weight, it should then have carried $\frac{27 \times 75}{85}$ = cwt. 23.8: therefore, as it broke with 7.7 cwt., it may, in round numbers, be estimated at one-third of the strength of a good hempen rope; and at two-thirds of the strength of such

white ropes as are generally sold in the interior country.—Had it proved to have been as strong, or nearly as strong, as hempen cordage, and equally capable of being protected from losing strength, either by heat or moisture, it then might have been useful as an appendage to cables; because one great occasion of anchors coming home, and cables parting in a storm and a heavy sea, arises from the instantaneous shock of the waves on the bows of the vessel, whilst the cable is kept extended by the pressure of the gale, and sometimes aided by the strength of the tide: therefore it is always found necessary, in heavy gales, to veer out much cable, that the vessel may ride easily by being able to recede from the shock of each wave, and readvance afterwards to its primary position:—a great length of cable, particularly in deep water, admits of it, partly from its elasticity, which is but small, but more especially from its superior specific gravity to that of water, which consequently occasions it to form a curved line, and draw the vessel forward immediately after the shock is past; by which means the effect of the impetus of the wave is reduced in a ratio more or less proportionate to the periods of the shocks and their intervals.—Wherever much cable is veered out, a great length of it necessarily rests on the ground; and it is clear that, in this part of it, elasticity must be destructive, by occasioning it to rub on the ground in every expansion and contraction; therefore it is a *desideratum* that cables should possess two qualities; viz. non-elasticity in the part next the anchor, and either gravity or great elasticity in the part extending from the ground to the ship's hawse. Chains, if well-known experience had not proved their great liability to fracture, possess advantageously the two qualities of lying quiescent near the anchor, and causing the vessel to advance by their gravity between the intervals of the waves: but if strength and elasticity could be obtained for the inner part of the cables, it would be preferable. It appears that a large portion of elasticity might be had from woollen ropes; but this quality is not available in them, from their want of strength, from the impracticability of obtaining any large quantity, and from its interference

with our woollen manufactory, so far as it might be attainable. In point of elasticity, coire ropes have much the advantage over those made of hemp, but they are unfortunately deficient both in strength and duration.

Elasticity in cordage, as already shewn, has its advantages and disadvantages: *some portion of it* is requisite in most instances, even for shrouds and backstays; as otherwise on the sudden * roll of a ship from a short over-hanging wave, they would oftener give way and lose the masts than at present; whilst at the same time a large portion of elasticity would, by receding too much, be productive of the same disaster. This leads me to speak of another quality of cordage, which is distinct from elasticity and injurious, I mean the stretching of ropes on their being strained with an increased stress. Every seaman knows, that masts have often been lost in long-continued stormy weather, by the stretching of the ship's shrouds, whilst there was no opportunity of setting them up tighter by taking up the lanyards, or from the *dead-eyes* coming a-block, so as to stop their being further taken up. Vessels are much more liable to this circumstance when their shrouds are made in the old way than on the new principle; and also more subject to it when the shrouds are *cabled,* than when hawser-laid; exclusive of the loss of strength from *that circumstance* if the primary strands be in both instances made of Mr. Balfour's twist, superseded by Mr. Huddart's, or what is now commonly called Patent, or registered cordage. The preceding assertions are founded on a number of experiments made on the elongation of ropes before breaking. What they are at the point of breaking, cannot of course be correctly known, but the mean of several experiments is as follows, when taken on twenty-four inches original length, which is shewn by the 2d column, whilst the 3d

* The effect of this is much reduced by the play given to the masts from the shrouds on the opposite sides being drawn together by the cat-harpens, both to admit the yards being braced up, and to resist the action of the foothook shrouds.

column shews the lengths they elongated to, when strained with seven-eighths of their breaking stress.

Registered *primary strands*	Inch. 24	24¾ to 25 Inches.
Registered shroud-laid ropes		26 to 26¼
Common-made shroud-laid rope		27½ to 28
Registered cable-laid rope		27 to 27¼

The property of stretching depends much on the press the ropes are laid with, and on their being *short* or *long* laid.

The three descriptions of rope stretch on an average one inch on twenty-four, with a fifth of their breaking stress, which amounts to from one half to two-fifths of the whole stretching of the register-made shroud-laid ropes, but only from two-sevenths to one-fourth of the stretching of the common-made shrouds, so that the latter, after the rigging is set up, will stretch about twice as much as the other, before it comes to its full bearing.

Having now discussed the stretching of ropes as quite distinct from elasticity; I shall revert to the subject I digressed from: viz. that it is a great *desideratum* to obtain the means of reducing the effect of the shocks of waves on vessels at anchor, by equalizing them with the period of their intervals, so far as practicable. One ingenious mode of doing it has sometimes been practised in small vessels, by attaching to the cable, at a suitable distance from the anchor, a large cask properly slung, and then veering out fifteen or twenty fathoms more: thus every wave which struck the vessel drew the cask under water, and its buoyancy returned it to the surface during the intervals, by drawing the vessel forward. It is evident that this mode can only be applicable to small sloops and cutters: I therefore shall suggest another method which is applicable to vessels of

any magnitude, viz. that of increasing the curvature of the cable downwards, during the interval of the waves; for which purpose, at fifteen or twenty fathoms (or more according to circumstances), from the extent of cable designed to be run out (and which is generally previously rounded with rope, or served with canvass and tanned bullocks hides, wrapped round and secured), I advise that it be served with canvass, and then rounded with a heavy short-linked chain, pointed at each end with a rope to cause it to pass easily through the hawse-hole. The effect of this weight is obvious; not only that it will draw the ship forward between the intervals of the waves; but, which is of more consequence, it will keep her always so far advanced towards her anchor, as to be ready to recede very considerably, on being struck by any extraordinarily large wave (for they are far from being uniform), which might otherwise start the anchor, or break it, or the cable. The method last recommended, is equally applicable to His Majesty's navy, or the merchants' service; as likewise is the following method, which has its peculiar advantages and disadvantages, and which of them would prevail, can only be known by experience. What I now allude to is, the worming * of ships' cables with chains in the following manner: viz. that the links of the worming chains should be circular and made of good iron, in which case they will elongate and become elliptic, as the cable stretches; and will add to its strength, and protect it considerably from being cut either by rocks, or from other causes. Previously to the laying on of this worming, it should be wrapped round with a very coarse hempen thread or band, made from the sweepings of a rope-ground, and over that (parcelled or) rounded with strips of canvass; and finally, with tarred spun-yarn laid on with a serving mallet. The hempen band and strips of canvass should be impregnated with whale

* Worming, in the common acceptation, is the winding in a spiral manner three smaller ropes in the cantlines or cavities between the strands of a greater one, and it is frequently done to the outer end of cables, to protect them from being worn upon the ground.

oil, and not with tar, because the latter superabounds with gallic acid, which would injure the iron *. Excepting the expense, which I conceive will be countervailed by the protection to the cable, the only peculiar inconvenience that I foresee is, that large cables which are unmanageable enough at present, may be rendered too stiff by it; but, whether it will be so or not, remains yet to be proved.

The bulk of a cable operates advantageously as well as its gravity, because the resistance of the water to the curved line of the cable becoming straight, which acts similarly to elasticity, is increased by it; and also, as rope is specifically heavier than water, it returns to its curved line more rapidly, not only from operating more forcibly on the ship, but because its tendency (under any given length) to become curved increases with its weight, and the resistance of the water to its assuming that form under any given celerity, increases only as the diameter of the rope. However, in all instances much aid will be derived from the mode of giving additional weight at a due distance from the ship, and as the period of the intervals is much longer than that of the shocks of the over-hanging waves, it follows that much more time is given for the rope to acquire its curvature, than to become comparatively straight; and therefore that those accidents which frequently happen *when a ship is struck by a heavy wave, whilst her cable is on a full stretch*, may be often prevented by the adoption of the preceding means.

When it is feared that a ship will not ride with one anchor, it is usual to let go a second, which has many inconveniences inclusive of the additional security being disproportionate to the additional means, from the moral impossibility of both cables bearing an equal strain, from which will arise a great defalcation of strength, probably superior to that which has

* Stockholm tar, and that from Archangel, are more corrosive than American tar, as every workman who has much occasion to have his hands smeared by it, will have experienced by the effect upon his skin.

been shewn to take place in the combination of primary strands into shroud-laid ropes, and of the latter into cables: therefore, as from the adoption of the new principle in men of war's cables, and the retention of their former magnitude, one cable will bear more strain * than two of the former cables from separate anchors; it becomes an object of consideration, *if the strength of the old cables was proportionate to that of the anchors*, whether it will not be advisable to increase the magnitude of one or more of a ship's anchors, and thus enable her to ride as safely with one anchor, as she has formerly done with two. I am aware of the greater difficulty of weighing anchors of increased size, and would now discuss the means of facilitating it, and of bringing up ships with greater safety to their anchors and cables, if it were not in some measure foreign to the original intention of this Essay, which I have already been led imperceptibly to digress from.

* Vide the Table of Comparison in page 24.

ERRATUM.

Page 16, *line* 18—for "April 30, 1799, Vide No. XX." *read*, "July 22, 1799, No. XIV."

EXPLANATION of PLATE I. belonging to INVENTION No. IV.

Fig. I. and II. *Machinery for slivering and drawing out the hemp, preparatory to its being spun into rope-yarn.*

Fig. III. *Yarn-spindle and bobbin.*

Fig. IV. *Perspective view of the machine for making ropes, in which* 1 *is the platform, by whose revolutions the three strands are twisted into a rope at* 2 *their point of junction; from which it is drawn forward as made by the revolution of the wheel* 4. 3, 3, 3, *are the separate strand-reels, each containing the requisite number and length of yarns necessary for a strand, and fixed in its respective strand-frame, revolving round its own axis at the same time that they are all carried round by their supporting frame* 1.

From the perspective mode of drawing having been adopted by the Patentee, part of the wheels and machinery are hid, and will be best explained by reference to the drawings of some of the subsequent Patents, on the same principle which have been given in plan and elevation, in the numbers of the Repertory referred to in the course of this work.

EXPLANATION of Plate II. belonging to INVENTION No. X.

Fig. I. and II. *Methods of stopping the twist of the hemp which were not adopted.*

Fig. III. *Gripping sheaves to hold a rope from slipping, and which (but in a greater number) are used on the sledge in* Fig. IV.

Fig. IV. *A side elevation of the tackle-board at the head of the ropery, and of the sledge departing from it to haul out and twist the strands. In this figure,* a *is the tackle-board, with a yarn-guide and press-blocks upon it, and with the lever to weight the blocks according to the magnitude of the strand. The upper half of the block rises or falls (perceptible only by the lever of the weight) with every incidental variation of the thickness of the strand; so that the resistance is always uniform, notwithstanding the interposition of two or three thick parts of yarns.*—c, c, *The ground-rope by which the sledge* b *is hove out by the motion of the wheels over which the ground-rope passes, and which motion keeps its due pace with the turning of the strand hooks.*—d, *A small windlass to tighten the ground-rope, the other end of which is made fast at the foot of the rope-ground.*

Fig. V. *A plan of the tackle-board and sledge, with part of their apparatus.*

Fig. VII. *A plan of the lower half of the press-block.*

Fig. VI. *An elevation of the upper and lower part of the press-block.*

Fig. IX. *The yarn-guide, or perforated plate, through which the rope-yarns pass individually to concentre at the press-block.*

Fig. VIII. *One of the strand-frames for making a rope on the new principle at one operation.*

A, *The upper division of the frame, with its reels, yarn-guide, press-blocks, and lever and weight, to make a primary strand after Mr. Balfour's principle; which, with the other two upper divisions, receives its motion from the wheel* i.

B, *The lower division of the frame, with its sheaves, round which the strand passes to compel it to receive the additional twist put into it by the wheel* h, *which is on the same axis with* i. *N. B. By mistake in the drawing, the comparative size of these wheels (and also of those they give motion to) is reversed.*— g, *A loose wheel on the same axis with* h *and* i, *and which receives its motion from the wheels* e *and* f, *which are connected together, and move freely on the axis of the lower division* B, *and receive motion from a bevel wheel on the lower sheaves, round which the strand passes; and the rope (or three strands combined under the extremity of a* fixed *top) is drawn away by the machinery of the rope-frame, in which the rope is wound up as made. The use of the described machinery is to compel all the three strands to come forward with an equable motion, without which one strand would appear higher than another in the rope. A platform on which a coil of shroud-laid rope may be placed for the purpose of making a cable or cablet, in which case the yarn-guide is taken away, and both divisions of the frame perform the same revolutions. The end of the rope is passed through the centre of the coil, and of the axes of the frames, which are hollow.*

Fig. X. and XI. *Shew a spindle calculated to spin and take away a rope-yarn, with any determinate number of turns, from women or children in a stationary position.*

EXPLANATION of PLATE III. belonging to INVENTION No. XIII.

Fig. I. 2. and II. *Represent spinning machinery for putting two twists into the rope-yarn at one operation.*

Fig. III. *Not of sufficient moment to describe here.*

Fig. IV. *The side elevation of a sledge, the machinery of which is moved by an endless rope, going with considerable celerity, and passing partially round the sheaves* q, q, r, *so as to give motion to them, which they communicate to the strand-hooks*—2, *Is a hauling rope, or chain, to draw the sledge backwards, which will be best explained by reference to*

Fig. V. and IX. *Plans of the sledge and of the machinery to draw it backward.* b, *A barrel (placed at the foot of the rope-ground) upon which the hauling-chain winds.* c, *A pinion acting upon a spur-wheel on the rim of the barrel.* a, *An axis with a grooved wheel at one end, round which the endless rope (*1. *in* fig. IV.*) passes.* x *and* y, *Two changeable pinions or small wheels, easily taken off and put on, and which are respectively to contain the precise number of teeth requisite to give the sledge such motion as may correspond with the size and revolution of the strands, for which the necessary tables are given to the foreman of the rope-ground.*

Fig. X. *Shews the additional machinery at the tail of a sledge when it is drawn back by sheaves acting on the ground-rope* 3, 3, *as described in the explanation of the preceding plate.—In all the roperies fitted up according to this Patent, the ground-rope has been made use of in preference to hauling back by the barrel.*

Fig. VI. *Machinery to move the strand-hooks at the tackle-board, which will be best explained by reference to the specification (which will be published at large in an early number of the Repertory of Arts).*

Figs. VII. and VIII. *Are the plan and elevation of a stake-head, with rollers to facilitate the twisting of a cable. These were not found necessary in practice.*

Fig. XI. *A contrivance at the tackle-board to put in the two twists of a primary strand at one operation, similarly to what has been described as the purpose of the divided strand-frame in* Plate II.; *but which was never carried into effect, because less simple than putting in the two twists at two operations.*

THE END.

S. Gosnell, Printer, Little Queen Street.

Fig. I.

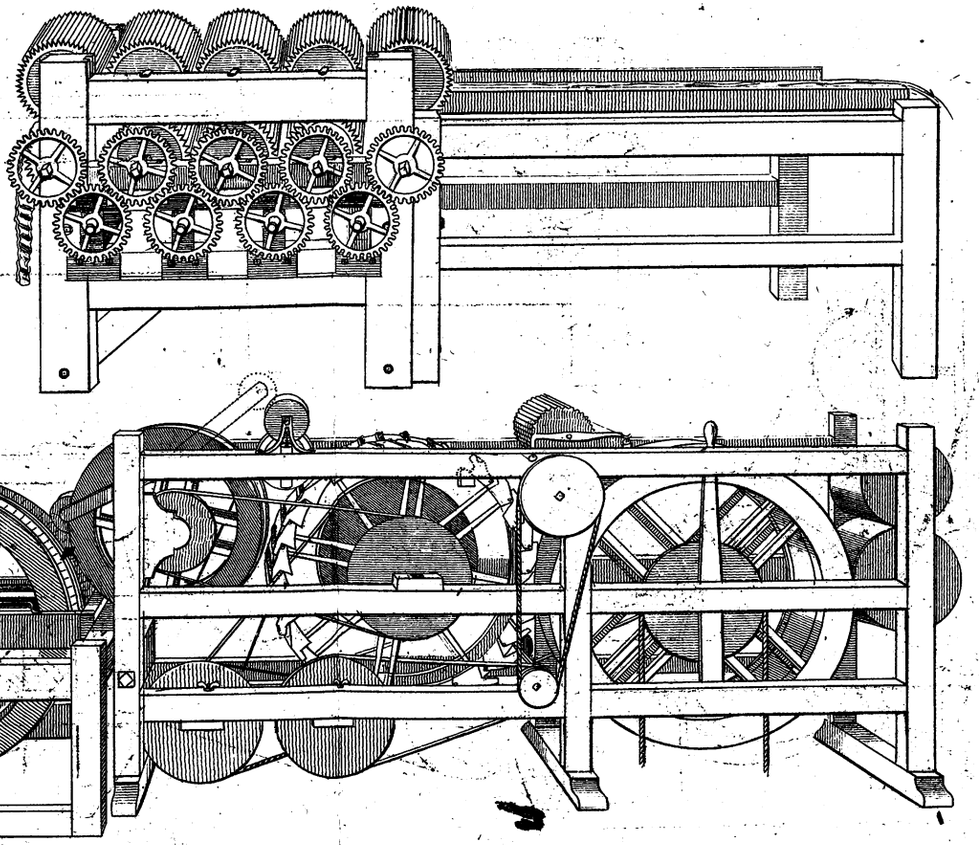


Fig. II.

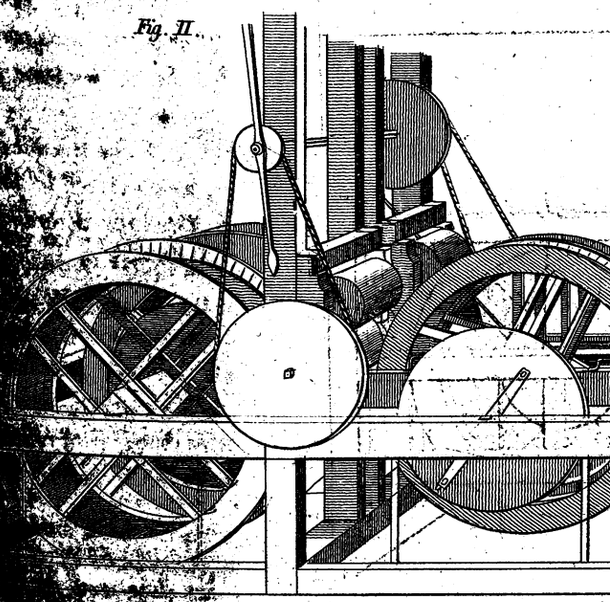


Fig. IV.

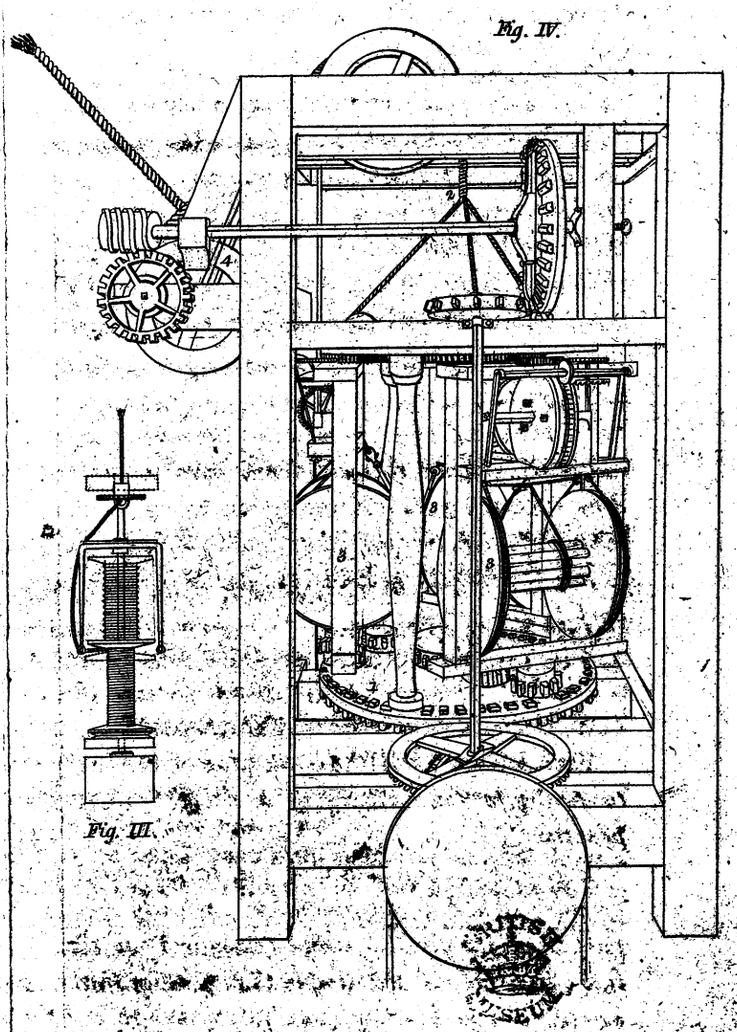


Fig. III.

Fig. XI.

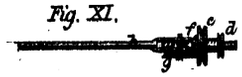


Fig. X.

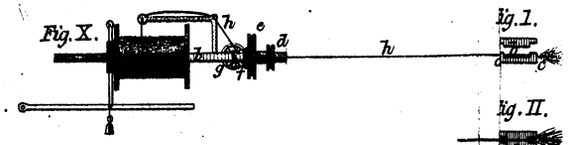
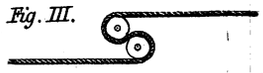


Fig. I.

Fig. II.

Fig. III.



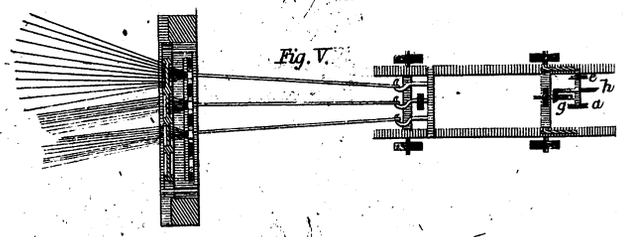
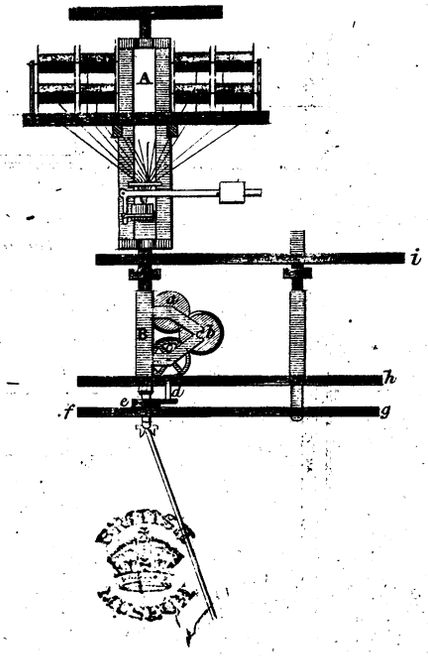


Fig. IX.

Fig. VII.

Fig. VI.

Fig. VIII.



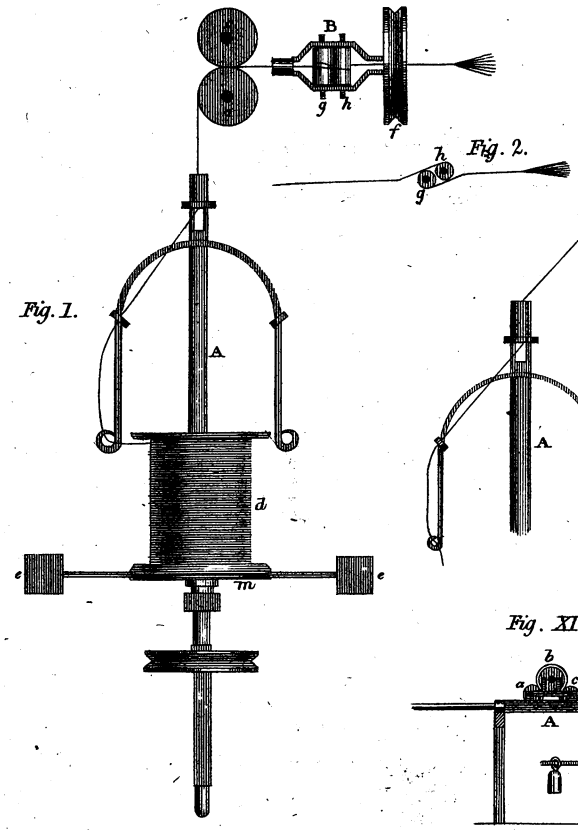


Fig. 1.

Fig. 2.

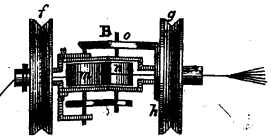


Fig. II.

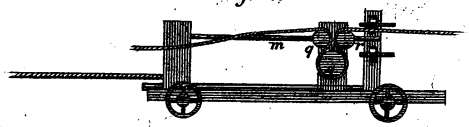


Fig. IV.

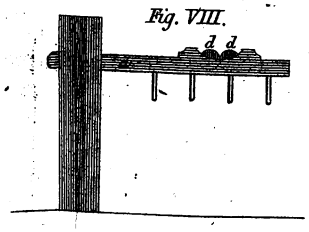


Fig. VIII.

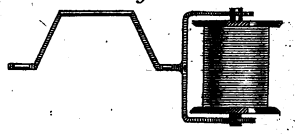


Fig. III.

Fig. XI.

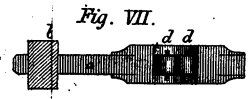


Fig. VII.

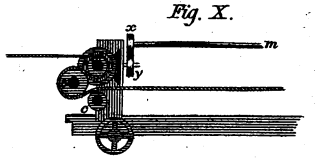


Fig. X.

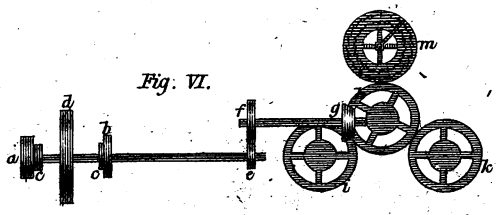


Fig. VI.

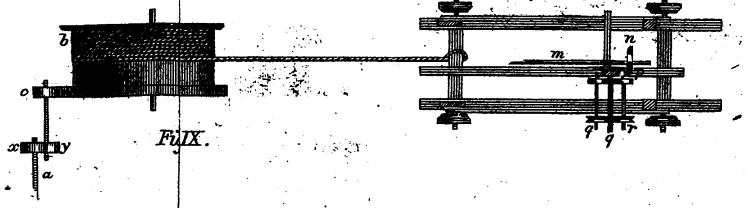
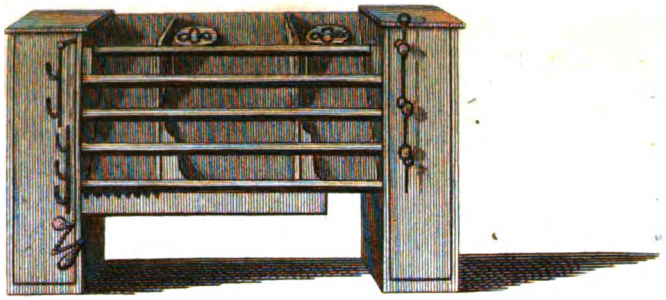


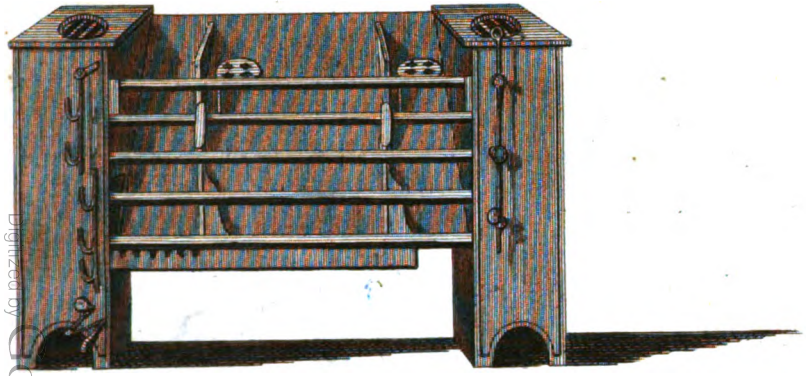
Fig. IX.

Fig. V.

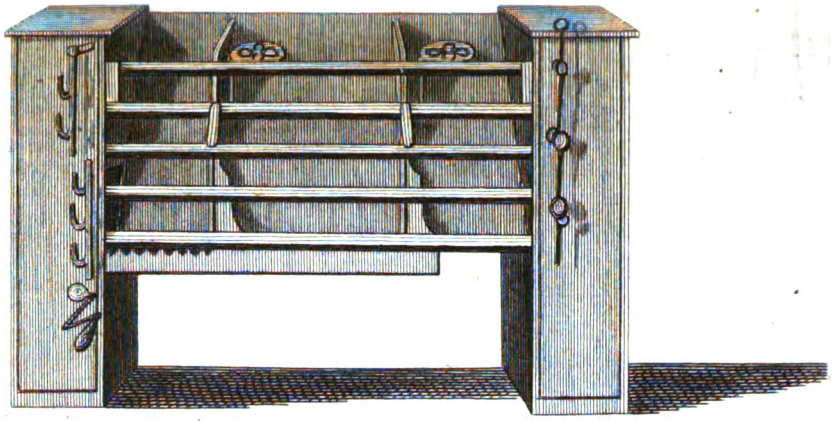


A Kitchen Grate, with Cast Iron Fronts & Hobs, made to fit any Size Chimney, with Mind-up Racks, Spit-hooks, Falling Bar, Pot Trivots & Back Compt.

Pl. 3.

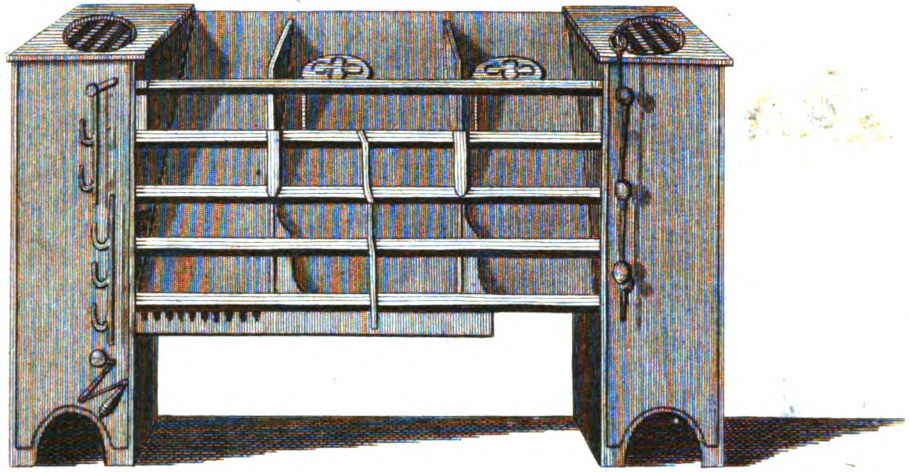


A Ditto same as Plates one & two with the addition of two Stewing Stoves in the Hobs.



A Ditto as Plate one, larger Size.

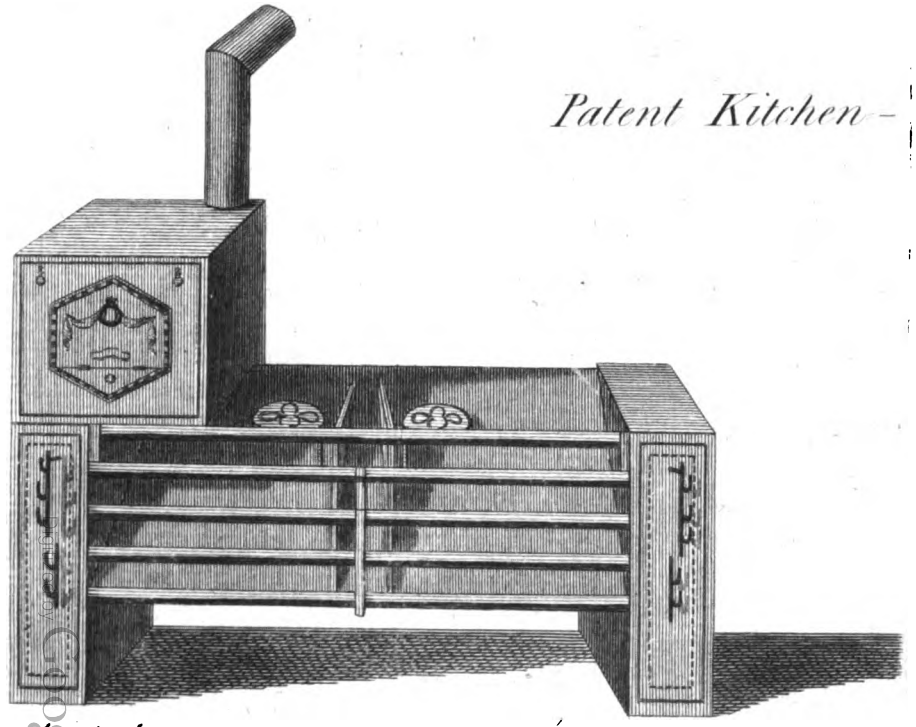
Pl. 4.



A Ditto as Plate three, larger Size.

Pl. 5.

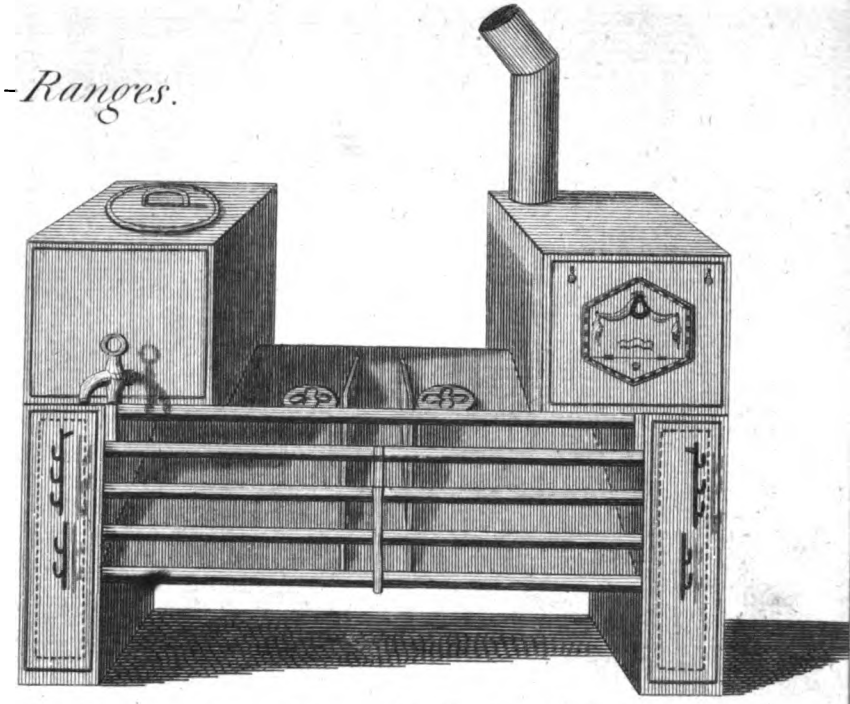
Patent Kitchen-



A Kitchen Range with an Oven heated by the same fire.

Pl. 6.

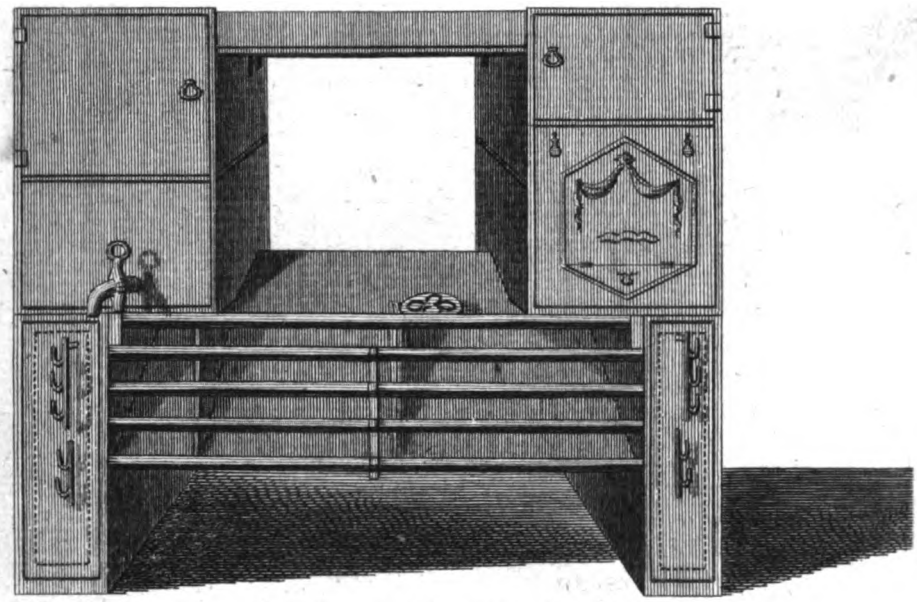
-Ranges.



A Ditto with an Oven & Boiler both heated by the same fire.

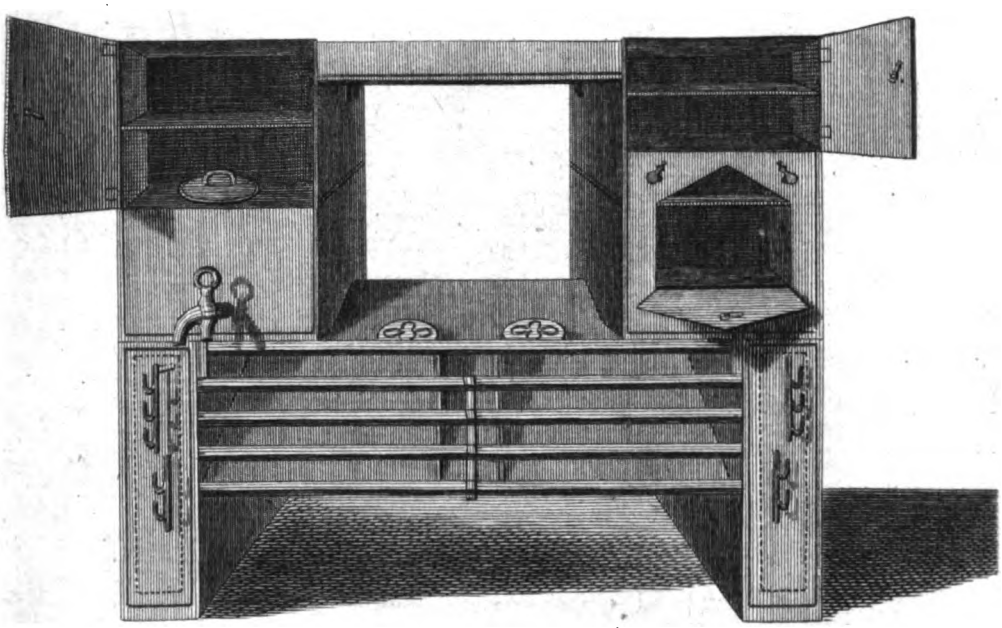
Pl. 7.

Patent Kitchen Range.



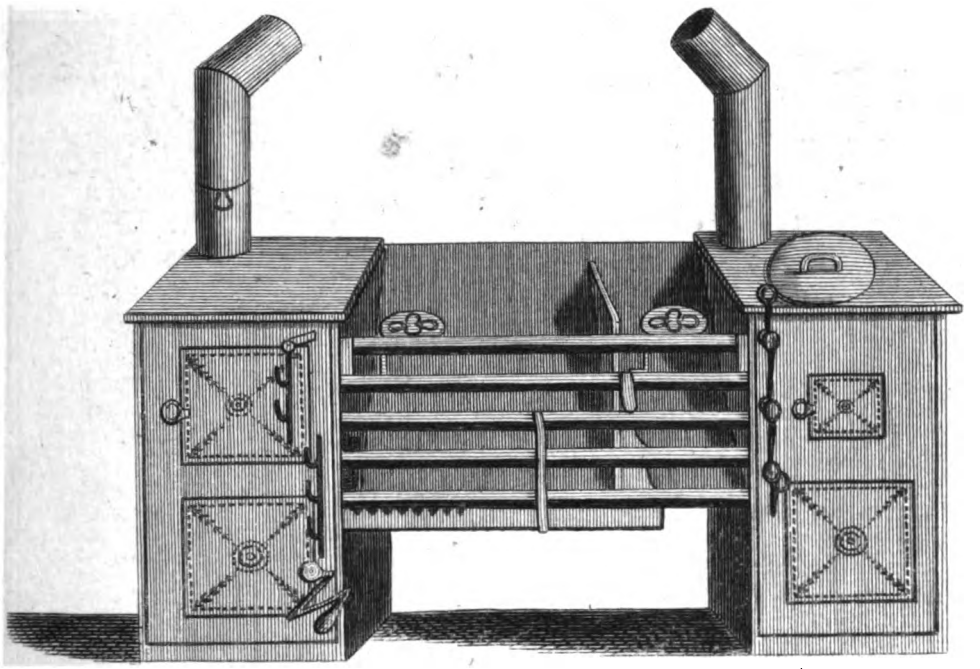
A Kitchen Range, with Oven, Boiler, Hot Closet, & Steam Ditto, all heated by the same fire.

Pl. 8.



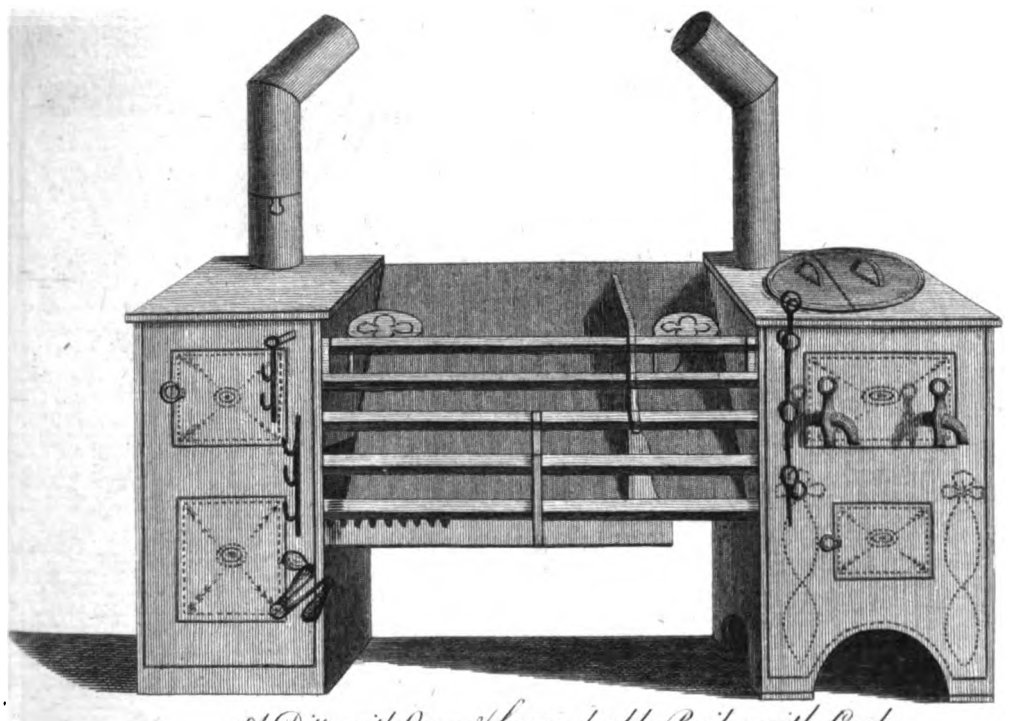
The same as Plate 7, with the doors open.

Pl. 9.

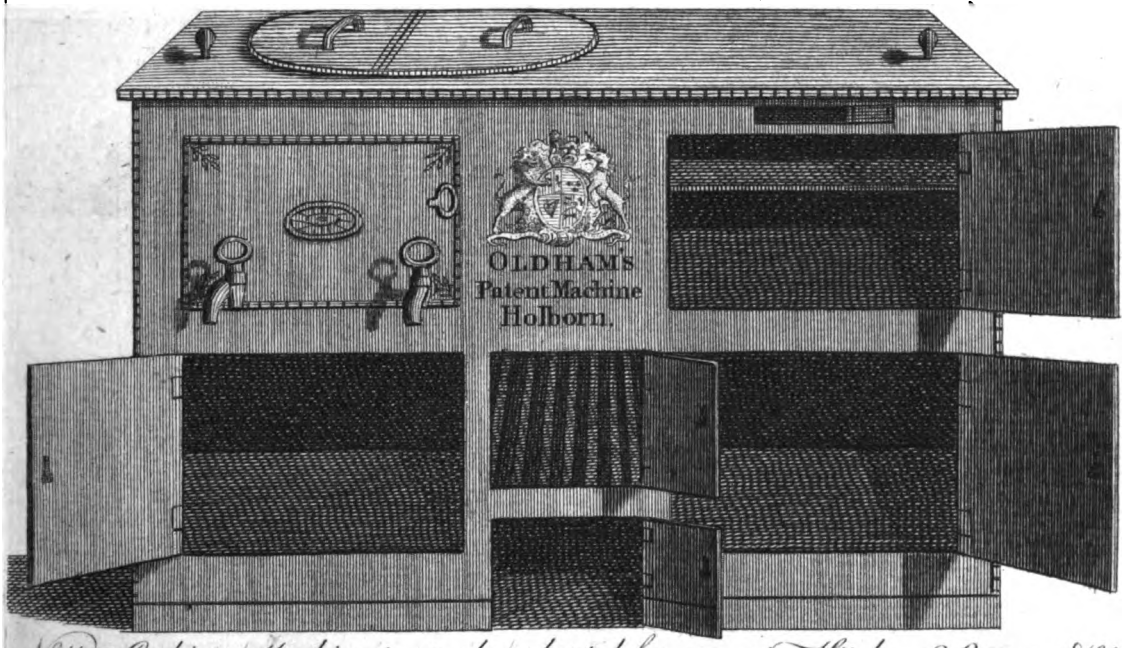


A Kitchen Range, with Oven & Boiler at each End, Oven heated by same fire.

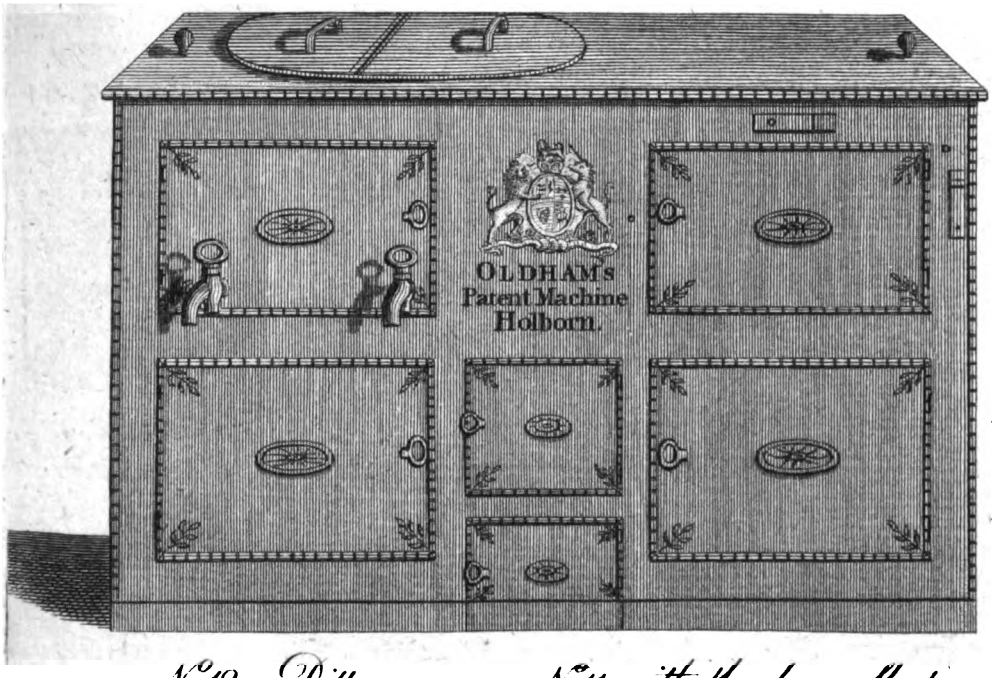
Pl. 10.



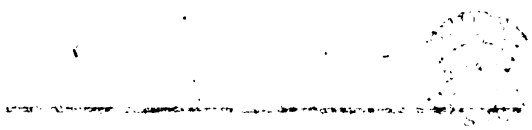
A Ditto with Oven & large double Boiler with Cocks.

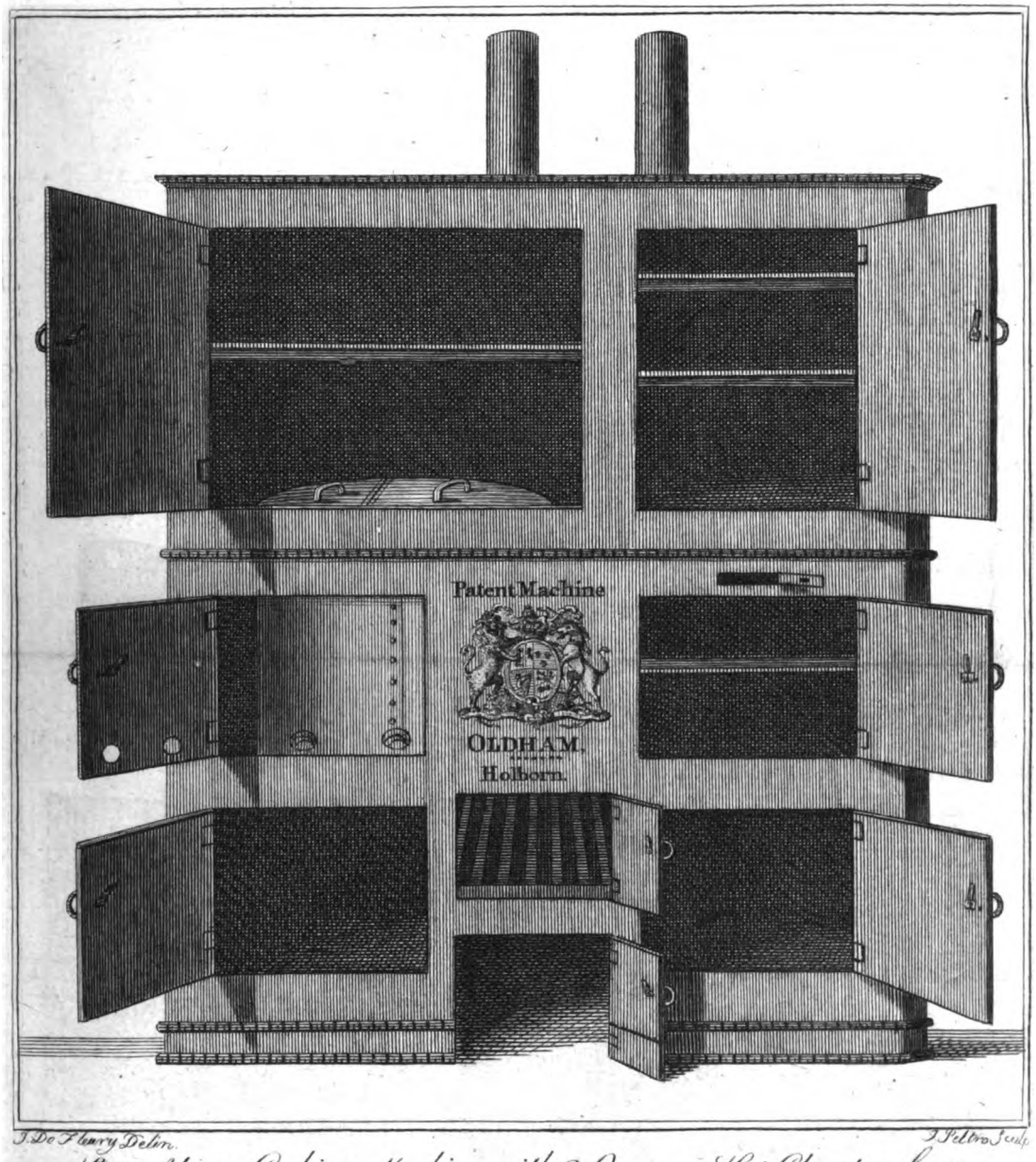


N.°11, a Cooking Machine properly adapted for any size Kitchen, 2 Ovens, a Hot Closet, & a large double Copper, with an Iron Hot Plate, all heated by one Fire.



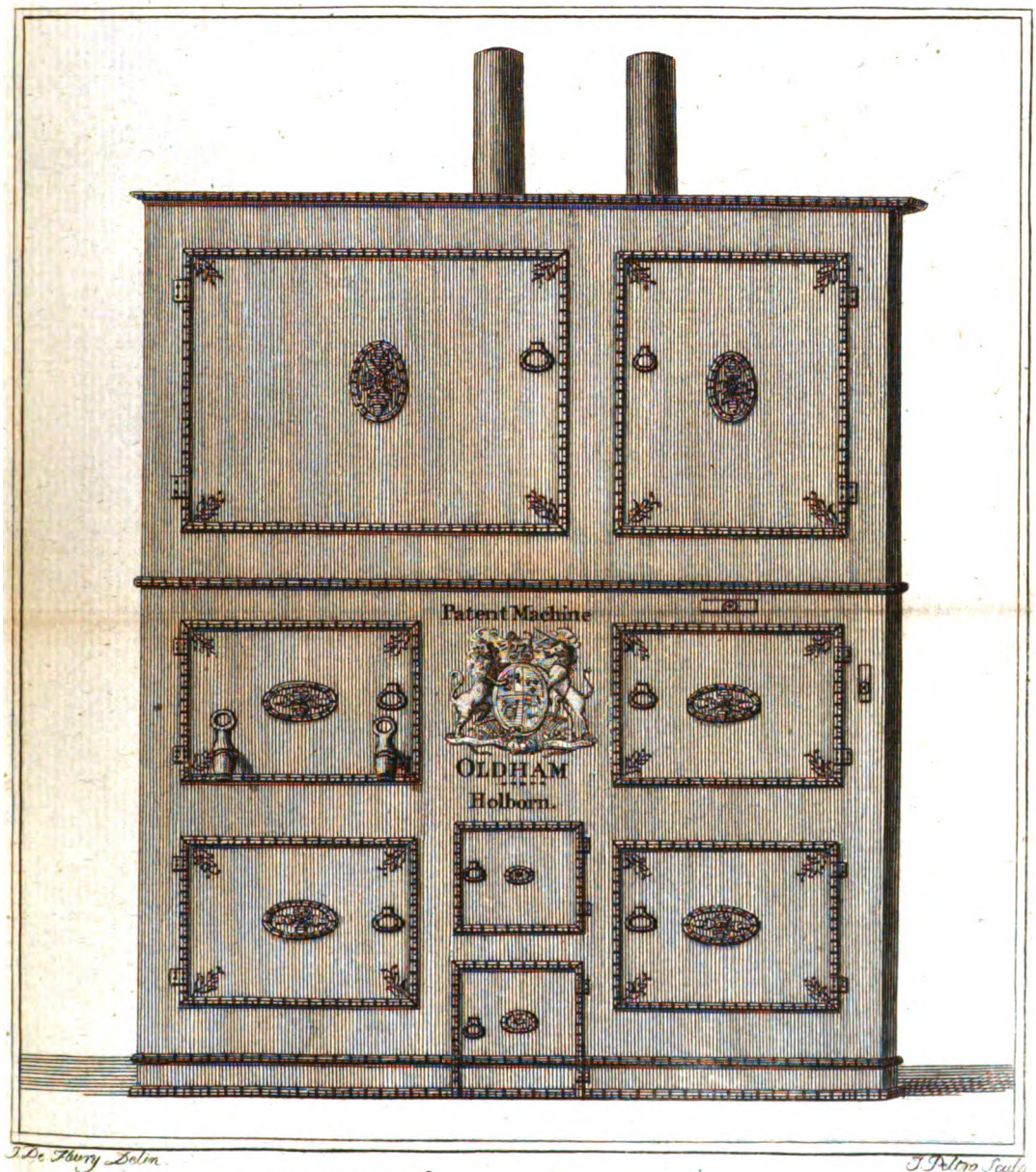
N.°12, a Ditto, same as N.°11, with the doors Shut.



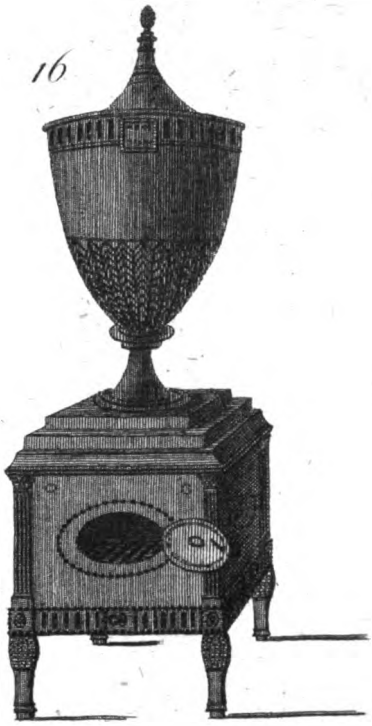


J. De Fleury Delin. J. Pelton Sculp.

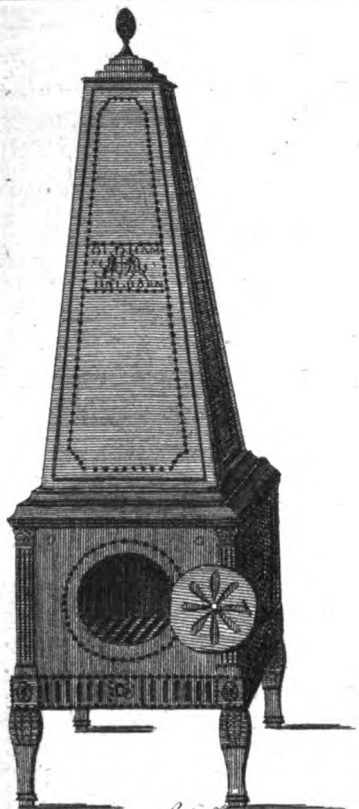
No 13, A large Cooking Machine, with 2 Ovens, a Hot Closet, a large double Boiler, Iron Hot Plate & Steam Closets, all heated by one Fire.

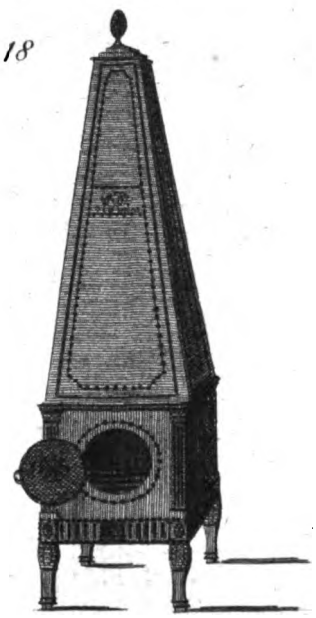


(N.º 14, a Ditto, with the doors shut, as N.º 13.)



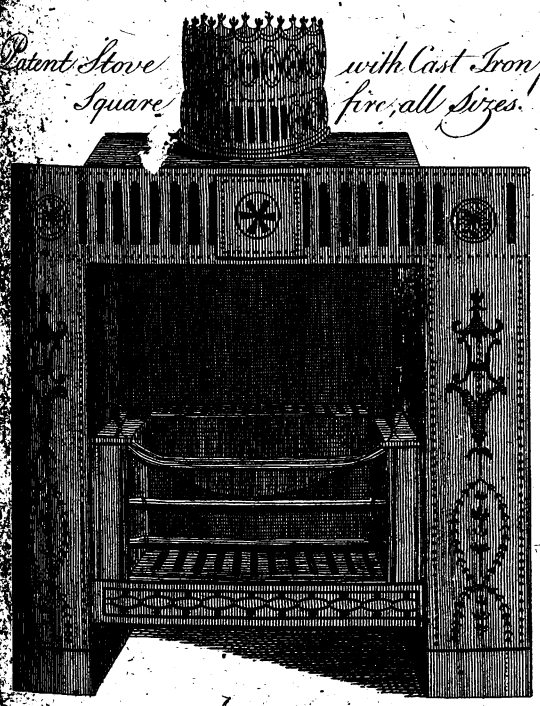
Patent Hot Air Tubes to each.



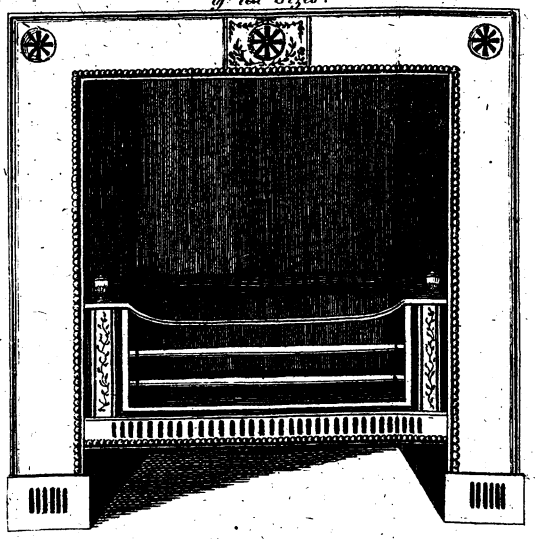


Warming Machines of different Sizes & Patterns for Churches, Halls, Stair Cases &c. &c.

Patent Stove Square with Cast Iron front fire, all Sizes.

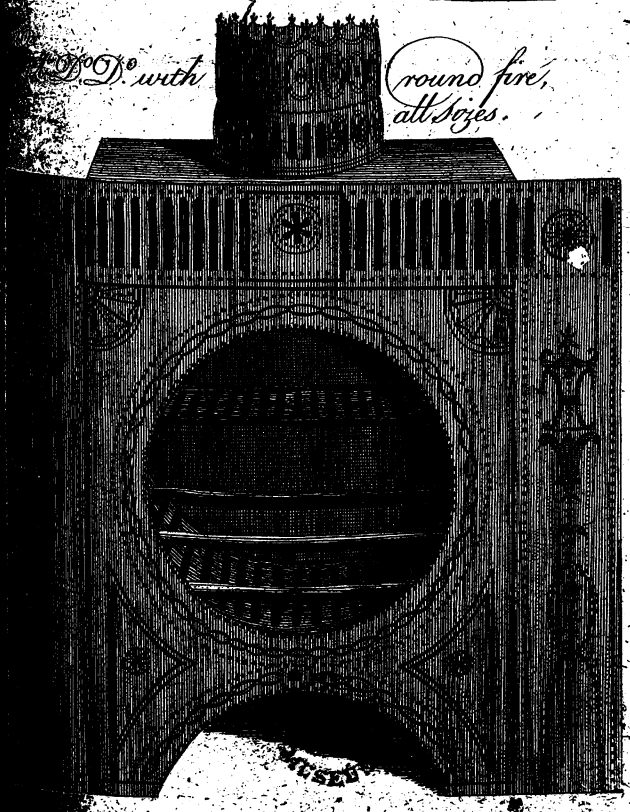


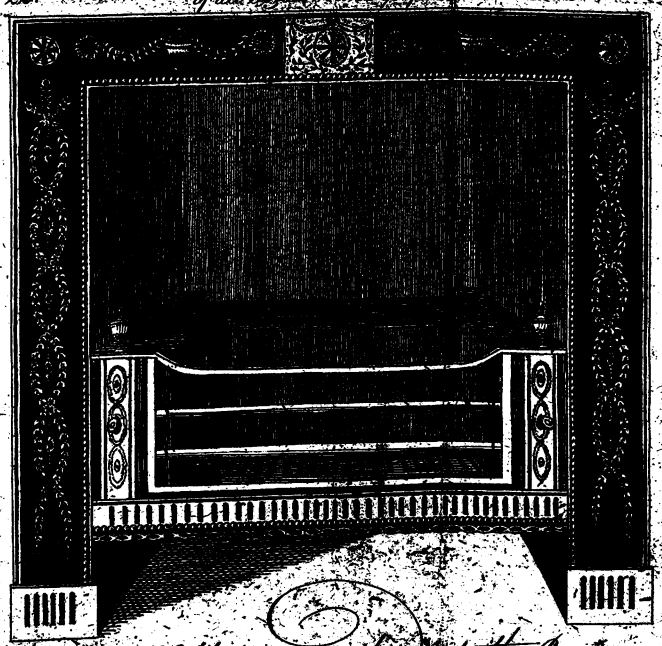
No 21. Patent Stove with Polished Steel front. of all Sizes.



Patent Stove with Japan'd, or Inlaid White Metal front.

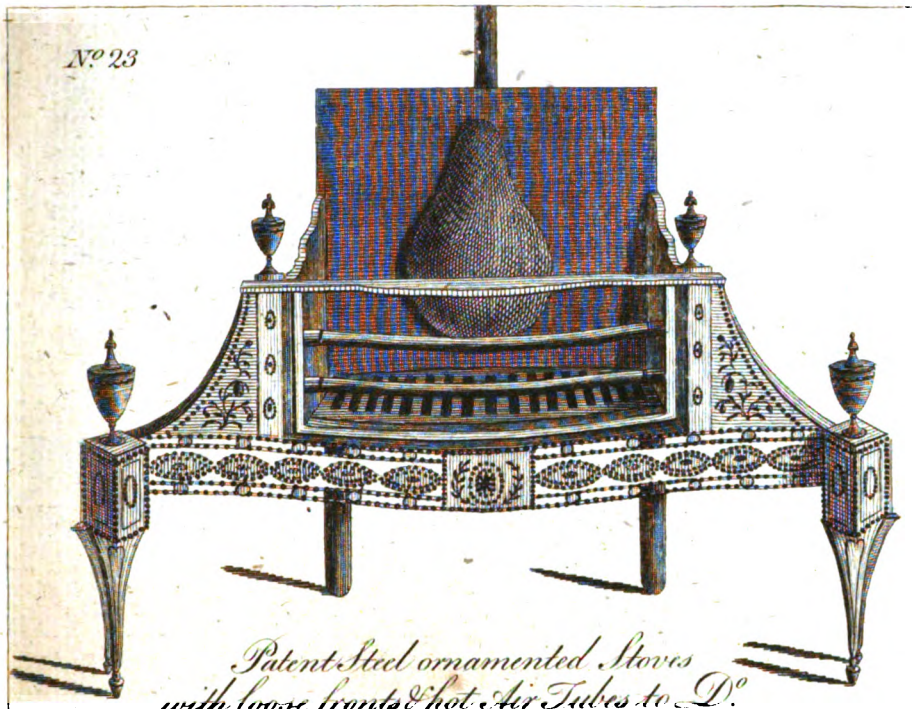
22. of all Sizes & all Patterns





N.B. Hot or Cold Air is introduced into the Room at pleasure from each of these Stoves.

No 23



Patent Steel ornamented Stoves
with loose fronts & hot Air Tubes to Do.
of all Sizes and Patterns.

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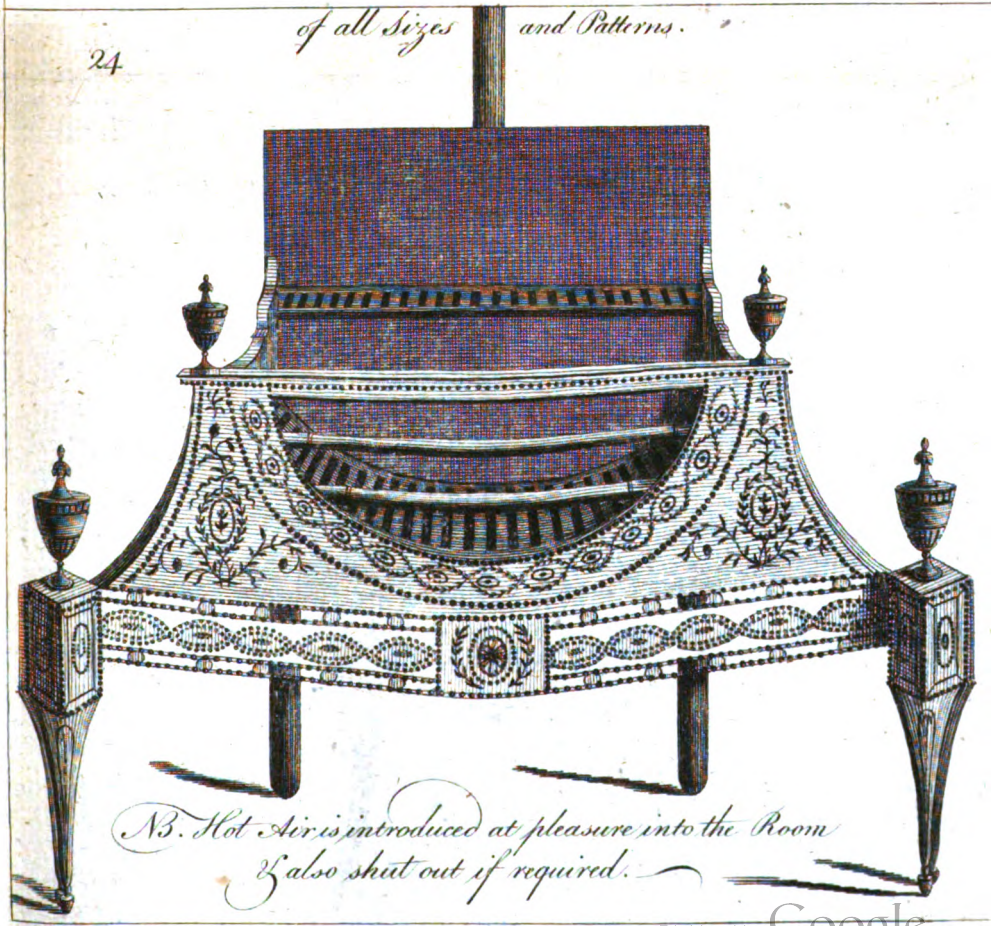

NB. Hot Air is introduced at pleasure into the Room
& also shut out if required.